The MINING CONGRESS JOURNAL

COPPER NUMBER

Featuring the operations of the Calumet and Hecla Consolidated Copper Company.

OCTOBER, 1931

GRADE CROSSINGS—

. . . are not dangerous for the driver who stops, looks, and listens, before crossing the track.

The same careful observance of proper procedure applied to the use of explosives makes blasting an inherently safe operation—especially when Ensign-Bickford Safety Fuse is used.

Nearly a hundred years of manufacturing experience are embodied in our present products. During this period coal mining has advanced from an extremely hazardous industry to one in which good engineering, good equipment, and strictly enforced rules have almost eliminated accidents in many modern mines.

We are proud of our long association with the Coal Industry and pledge our continued support to every movement in behalf of safer blasting.

THE ENSIGN-BICKFORD CO.
SIMSBURY **CONNECTICUT**

Do Not "Short Fuse" --Fuse should be cut long enough for the end to extend well out of the mouth of the bore hole when the primer cartridge is in place.
All holes should be well tamped.

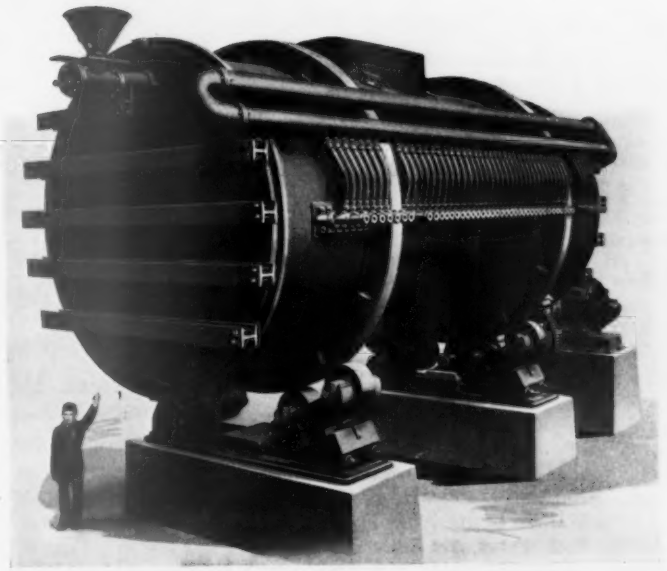
THE ENSIGN-BICKFORD CO. 1836 SAFETY FUSE 1931 SIMSBURY, CONN.

In Every Part of the Plant

- - - the Copper Industry uses A-C Machinery

For more than seventy-five years Allis-Chalmers has furnished a large part of the equipment used by copper mines throughout the world. Allis-Chalmers through close cooperation with the men of the industry who improved old methods and discovered new processes contributed to the growth and success of the industry by producing the mechanical equipment necessary in making the new processes and methods commercially operative.

Above: Copper Smelting Furnace
Right: Pierce Smith Copper Converter



Equipment for Copper Mines

Electric Hoists
Ore Sampling Equipment
Smelting Furnaces
Slag Cars
Skull Breakers
Copper Converters
Casting Furnaces
Casting Machines
Crushing Equipment
Screens

Electric Power Generating and Driving Equipment

Motors Texrope Drives Pumps

Blowers and Compressors

ALLIS-CHALMERS

Allis-Chalmers Manufacturing Company, Milwaukee

THE MINING CONGRESS JOURNAL

VOLUME 17 OCTOBER, 1931 No. 10

Contents

FEATURE ARTICLES

The Copper Industry—By Robert E. Tally 463
CALUMET AND HECLA CONSOLIDATED COPPER COMPANY—
Review of the Copper & Brass Research Association—By R. L. Agassiz 467
Historical Sketch of the Lake Superior Copper District—By James Fisher 468
Alexander Agassiz and The Early History of the Calumet and Hecla—By George R. Agassiz 473
History of the Calumet and Hecla Since 1900—By James MacNaughton 474
Geology and Exploration in the Michigan Copper District—By T. M. Broderick and C. D. Hohl 478
Mining Methods in the Amygdaloid Lodes—Kearsarge Lode Operations—By Ocha Potter 482
Mining Methods in the Amygdaloid Lodes—Osceola Lode Operations—By Ocha Potter and Samuel Richards 487
Shrinkage Stoping in Amygdaloid Lodes—By A. H. Wohlrab ... 491
Mining Methods Used on the Calumet Conglomerate Lode—By Harry Vivian 496
Underground Power Distribution and Haulage—By Carl L. Fichtel 503
Underground Safety Work—By J. W. Alt 507
Hoisting Equipment and Methods—By Thos. P. Soddy and Allan Cameron 509
Transportation System and Coal Dock—By Frank H. Haller ... 515
Milling at the Calumet and Hecla Consolidated Copper Company—By C. H. Benedict 519
Flotation Practice at the Calumet and Hecla—By Robert M. Haskell 528
The Historical Development of Smelting and Refining Native Copper—By H. D. Conant 531
Present Smelting Practice—By E. R. Lovell and H. C. Kenny ... 533
Electric Power Generation—By Robert McIntosh and A. L. Burgan 539
Electric Power Distribution—By Frederick N. Bosson 547
Mine Surface Plants—By H. E. Williams 549
Purchasing Department Procedure—By E. C. Messner 552
Supply Department Procedure—By P. J. McClelland 553
The Medical Department—By P. D. Bourland, M.D. 555
Safety and Accident Prevention Policies—By O. F. Bailey 558
Calumet and Hecla Library—By Mrs. M. F. Grierson 561
Industrial and Community Relations—By John G. Bennetts 563
Cost Accounting Methods—By A. D. Nicholas 565
Safety Organization at Mines of the Utah Fuel Company—By D. J. Parker 566
Maintaining Discipline—By Thos. G. Fear, Milton H. Fies, John H. Richards and I. N. Bayless 568
Modern Mining with Conveyors in Wide Rooms and Modified Long Faces—By G. B. Southward 572

EDITORIALS

Major Requirements for Stabilizing Copper 459
Copper and Progress 460
Problems of Mining Industry 460
Stabilization of Production 460
The Way Out for Mining 460
One Idea of Stabilized Industry 461
Taxing Our Way Out 461
What Is Money 461
Gold 461
The Cost of Machinery 462
Getting Talked About 462
Our Pet Topic 462
Russia and American Mining 462

DEPARTMENTS

PRACTICAL OPERATING MEN'S DEPARTMENT, COAL 566
REPORTS ON THE MECHANIZATION SURVEY 572
NEWS OF THE MINING FIELD 574
WITH THE MANUFACTURERS 585

Practical Operating Men's Department

COAL

Safety Organizations at Mines of the Utah Fuel Company

Maintaining Discipline

METALS

[Due to the cooperation of Mr. Guy N. Bjorge, Associate Editor, in the preparation of the articles on the operations of the Calumet and Hecla Consolidated Copper Company which appear in this issue, the Metals Section of the Practical Operating Men's Department is omitted.]

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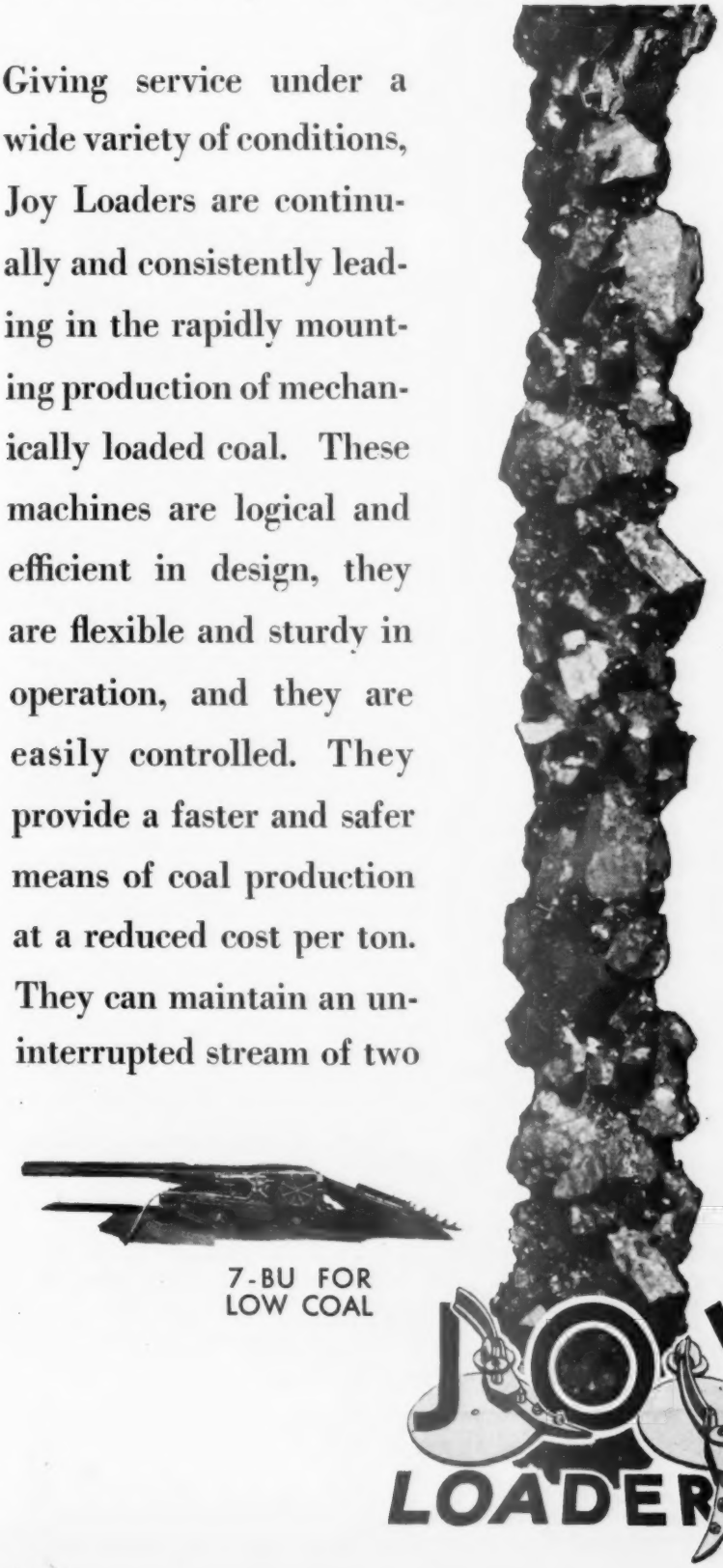
A steady stream at two tons per minute

Giving service under a wide variety of conditions, Joy Loaders are continually and consistently leading in the rapidly mounting production of mechanically loaded coal. These machines are logical and efficient in design, they are flexible and sturdy in operation, and they are easily controlled. They provide a faster and safer means of coal production at a reduced cost per ton. They can maintain an uninterrupted stream of two tons of coal per minute. Their adaptability and steady efficiency help reduce mining handicaps and their savings help to stabilize your profits. Let us survey your mine for the possibilities and advantages of Joy loading. The 5-BU operates in seams from 60 inches up. The 7-BU will operate in a 48-inch seam. Each has the same two-ton per minute capacity and each has one-man control. Joy Manufacturing Company, Franklin, Pennsylvania.



7-BU FOR LOW COAL

5-BU FOR HIGH COAL

JOY LOADERS

MANY MILLIONS *of* DOLLARS *are Spent each year for* NEEDLESS TIMBER REPLACEMENTS

GRASSELLI

MINE operators spend millions of dollars annually for mine timbers. A *large part* of this expenditure is for replacements due to rot. This tremendous waste can be avoided by the use of treated timber for all main workings.

Untreated timbers usually require replacement every 3 to 6 years. Zinc Chloride treated timbers have been shown by numerous actual tests to be still sound and serviceable after 12 to 20 years exposure!

Zinc Chloride treatment adds but little to the cost of untreated timbers, yet it prolongs their life many times. It eliminates costly replacements and reduces maintenance expense. It is a wise economy to preserve mine timbers with Zinc Chloride.

Zinc Chloride treated timbers not only have longer life, but they are fire-retarding as well — thus insuring an additional factor of safety.

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Send coupon below for illustrated booklet "Looking Ahead Twenty Years" sent free on request.

Commercial treating plants are located conveniently near you. They are equipped to treat under pressure every structural or mine timber you will require. Write us for their names if you wish.

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GRASSELLI ZINC CHLORIDE

A Positive Preventive of DECAY in Mine Timbers

A *NEW* Low Cost-High Speed Post Drill

Patents pending.

THE JEFFREY COMPANY again comes to the fore with another achievement for the mining industry—a rotary type drill for use in drilling coal and similar material.

The Jeffrey A-6 Lightweight Post Drill is entirely new in design and construction—it embodies some distinctive features not found in other drills.

Drilling holes with this new Jeffrey Post Drill is easier and speedier than with any light drill ever before developed. Since the drill is light in weight it may easily be placed in the cradle support on the post and lifted to the drilling height.

With a fast speed of 43″ per minute forward and 216″ per minute return, drilling time is greatly reduced. The rapid return speed of the auger without reversing direction of rotation cleans the holes of all cuttings.

Long life and low maintenance are assured through the use of anti-friction bearings, combined with effective lubrication.

Supplied in open type for use in open light mines and the Government Approved, totally enclosed or flameproof type for gaseous mines.

The Jeffrey Manufacturing Company
958-99 North Fourth St., Columbus, Ohio

This new Folder No. 532-A completely describes the Jeffrey A-6 Post Drill.

Write for your copy NOW.

Jeffrey
56-A Drilling Machine (Patented)

The illustration below shows the Jeffrey 56-A Drilling Machine in operation—it drills two holes simultaneously. The augers driven by independent motors and mounted on independent arms and turntables are adjustable for drilling holes anywhere between the floor and roof without leaving track.

The 56-A Machine is mounted on a self-propelling truck—the arms can be folded up for tramming. It trams as fast as a gathering locomotive—no time is lost in unloading drills, setting them up, taking them down, or loading them back onto truck.

Write for complete particulars.

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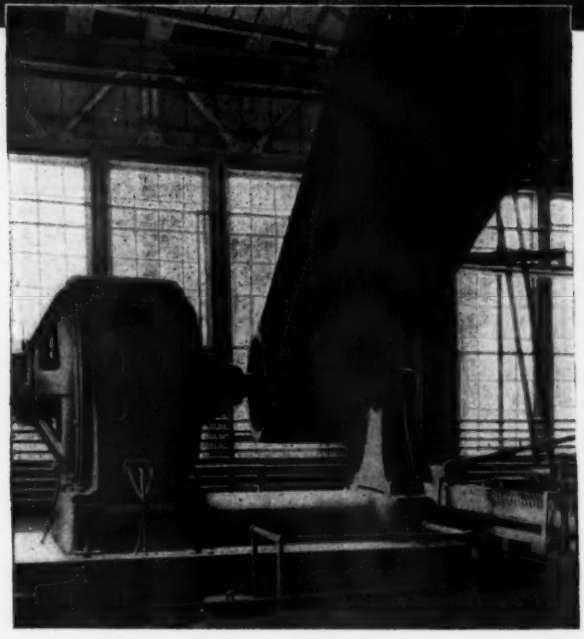
Jeffrey Manufacturing Co., Ltd., of Canada. *Head Office and Works*, Montreal; *Branch Office*, Toronto; *Service Station*, 210 Ninth Ave., W. Calgary

JEFFREY COAL MINE EQUIPMENT

Two Decades *of*

Regrinding plant of Calumet & Hecla Consolidated Copper Co., Calumet, Michigan, showing the double-row of 64 G-E motors—each of which has been in service for nearly 20 years—not one of which has ever burned out



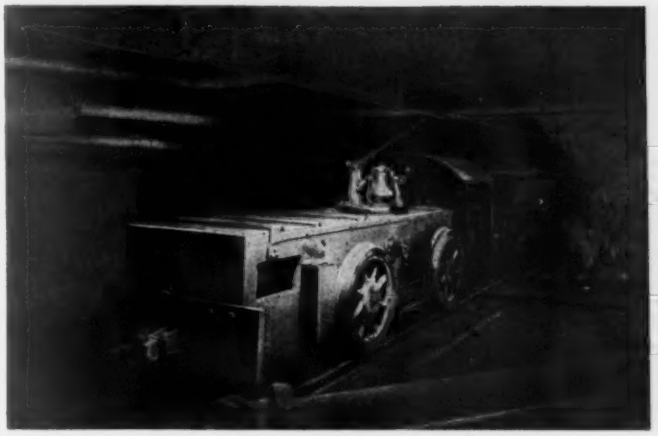
One of eight G-E 250-hp. motors driving conical mills and jigging tables at the No. 1 grinding plant

Electrical Service *to* Calumet & Hecla Consolidated Copper Co.

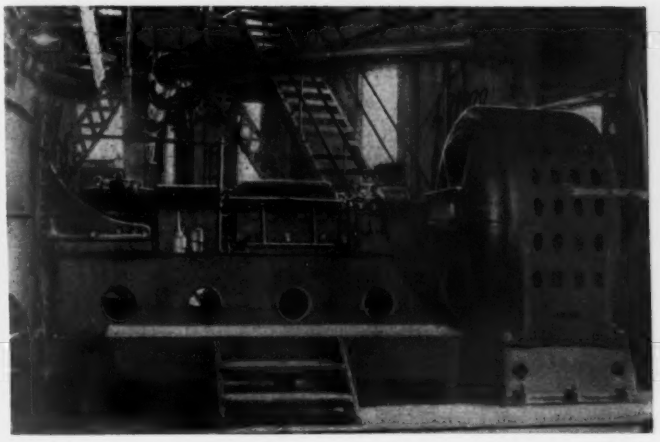
NEARLY 20 years ago, the Calumet & Hecla Consolidated Copper Company installed 64 G-E 40-hp. motors in its regrinding plant. These motors have been running almost continuously—24 hours a day, 7 days a week—*and not one has ever burned out*. The confidence of the mining world in G-E equipment is based on records like this.

To-day, there are approximately 600 G-E induction motors, totaling nearly 35,000 horsepower, operating on this mining property. A mile below the earth's surface, a complete G-E substation is in daily operation. At other important places—on dredges for driving pumps, on casting machines, jigging tables, conical mills, above ground and below, are many other G-E motors serving reliably and efficiently.

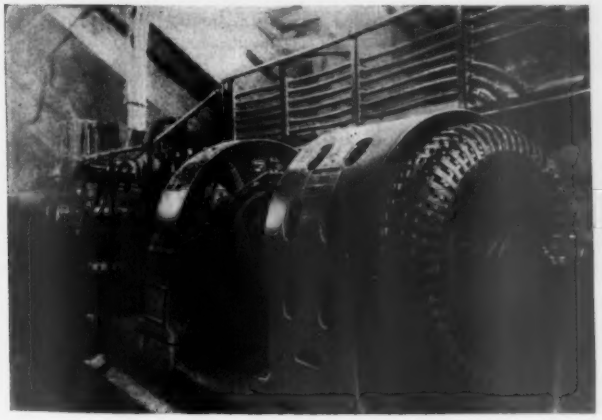
There is no power need of mining tha cannot be met with G-E equipment. Why not let your nearest G-E office be of service?



G-E 13-ton mine locomotive at Red Jacket shaft



(Above) One of two G-E 1250-hp. motors installed respectively on two dredges



(Left) G-E 250-kw. motor-generator set at Red Jacket shaft

200-495

GENERAL ELECTRIC

SALES AND ENGINEERING SERVICE IN PRINCIPAL CITIES

"SERVICE is primarily considered to be that assistance which the Technical Service representative furnishes the customer in the selection, and application of the grades of Dynamite and the Blasting Supplies to be used. Secondarily, it includes provisions regarding deliveries."

....But Giant Service Begins Before that....

...and includes:

A technically advised Purchasing Department working in conjunction with our Laboratories to obtain the best and most suitable ingredients.

Development and Research Laboratories, consisting of specialists on explosives without the distractions of side interests.

Engineers who see that all formulæ processes and materials are understood and properly applied by factory management.

A uniform system of factory inspection and product examination.

Consistent review of the world-wide situations in explosives, that our customers may have the advantage of all worth while developments.

A system for training and instructing Sales representatives which involves intimate contact with our factories and laboratories.

Giant Service is responsible for Giant Quality which characterizes Giant products for *all* blasting requirements.

TEST FOR FREEZING RESISTANCE

The above sketch illustrates the method that has been used to determine the freezing resistance of Giant Dynamites. With the development and use of an Explosive that most effectively immunizes Dynamites against freezing, this test has become somewhat unnecessary, for experience has proven that all Giant Dynamites are practically non-freezing.

GIANT
EXPLOSIVES

GIANT

The GIANT POWDER COMPANY, Con.

Crocker First National Bank Building
SAN FRANCISCO, CALIFORNIA

Branch Offices: Butte, Mont., Seattle, Wash., Salt Lake City, Utah, Portland, Ore., Spokane, Wash., Los Angeles, Calif.

The GREATEST ARCHITECTS *say*

"For minimum upkeep cost use

COPPER, BRASS *and* BRONZE"

In appropriate uses, Copper and its alloys contribute to successful design. Examples are the harmonious patina of lasting Copper roofing, and the practical adornment of enduring ornamental Bronze. Copper, Brass and Bronze are recognized as fundamentals for certain architectural interpretations.

"—iron may last ten years and may give out in three years; Copper and Brass ought to last as long as the building."

Designers of the new Wall and Hanover Building, New York

"When one considers how very little more Copper and Brass now costs, it seems very foolish economy to gamble with the rust troubles that so often occur when corrodible metals are used."

Designer of the Bush Building New York

"We favor the use of Copper, Brass and Bronze materials wherever possible, because experience has shown that ultimately they prove to be the most economical."

Designer of Library Building, University of Washington

"When one considers the years of rust-free service that Copper and Brass give, their slightly higher initial cost seems a very small item indeed."

Designer of the Lincoln Building, New York

"Even when Copper and Brass were very much more expensive than they are today, we recommended them to our clients as proving a real economy in the long run."

Designers of the Industrial Trust Building, Providence, R. I.

"Although they cost a little more in the beginning, Copper, Brass and Bronze invariably prove a real economy in the long run."

Nationally known school architect and designer of the Continental Life Insurance Company Building in St. Louis

"There are no repairs of a building more annoying or more costly than those that are necessitated by rusting metals."

Designer of the Tribune Tower, Chicago

"Copper and Brass are accepted as practically standard equipment in all buildings where permanency is a primary requisite."

Designers of the New York Times Office Building

"There is no question that where permanency is the paramount consideration, Copper, Brass and Bronze materials become essential."

Famous designer of churches throughout the country

"We have used and are using a great deal of Copper, Brass and Bronze in our work, thereby avoiding deterioration and making our buildings as nearly permanent as possible."

Designers of the Kansas City Life Insurance Company Building

"The use of Copper, Brass and Bronze in buildings today is getting more and more common and we feel that in the near future they will entirely supplant the ferrous metals wherever corrosion is to be contended with."

Designer of Allerton Houses in New York and Chicago

ONE of the functions of the Association is cooperation with architects in all problems concerning the uses and proper application of Copper, Brass and Bronze in building construction.

COPPER & BRASS
RESEARCH ASSOCIATION

25 Broadway, New York

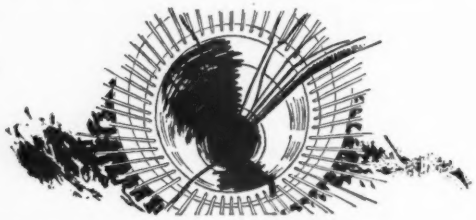
Southern Office	*Canadian Office*	*Pacific Coast Office*
Shoreham Building	67 Yonge Street	Architects Building
Washington, D. C.	Toronto, Canada	Los Angeles, Calif.

What is *Your*

There is a du Pont Explosive

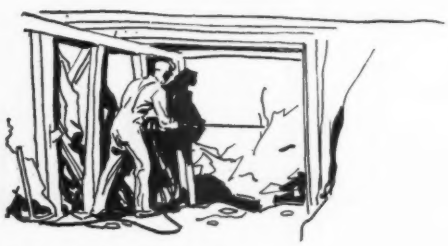
QUARRYING

For shale and soft limestone, first choices are du Pont Extra and Red Cross Extra. Durox is second. For granite and hard limestone, first choice is du Pont Quarry Gelatin. Second choice—du Pont Gelatin or Special Gelatin.



TUNNELS and DRIFTS

Several explosives are recommended for blasting tunnels and drifts. Du Pont Gelatin and Special Gelatin are recommended as firsts. For hardest rock only, use Blasting Gelatin. For tunnels in coal mines, use the Permissible, Gelobel. Red Cross Extra may also be used in blasting tunnels.



COAL MINING

Whatever the type of coal seam—whether your mine is gaseous or non-gaseous—you can use du Pont Explosives with assurance of satisfactory execution and good lump coal. Du Pont offers a complete series of Permissibles and Pellet Powders.

ORE MINING (*Underground*)

Du Pont Gelatin and du Pont Special Gelatin—The first is particularly good for work under high water pressure. The second is the standard explosive for shaft sinking. Both are used for hard ore. The du Pont Extras and Durox are also used.

ROADS and RAILROADS

The best all-around explosive for this type of work is Red Cross Extra. For very hard rock only, first choice is du Pont Quarry Gelatin. Second choice is du Pont Gelatin or du Pont Special Gelatin. First choice for deep sprung holes, soft material, is granular Blasting Powder.

FILL SETTLEMENT

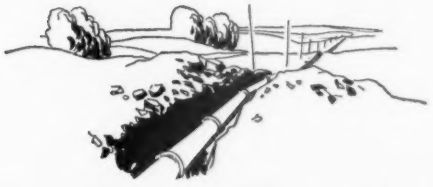
First choice for this type of work is du Pont Gelatin, which has maximum of plasticity and water resistance and gives off minimum of fumes. Du Pont Special Gelatin may also be used where there is less water.

DU PONT

REG. U.S. PAT. OFF.

BLASTING JOB?

made especially for it



TRENCHES FOR PIPE LINES, WATER MAINS AND SEWERS

For general work of this type, Red Cross Extra is recommended as first choice. First choice for hard rock is du Pont Special Gelatin; second choice, du Pont Gelatin.

GYPSUM MINING

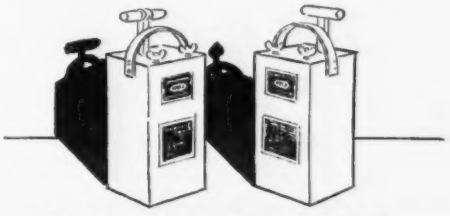
For first choice, either du Pont Gelatin or du Pont Special Gelatin, or Gypsum A (manufactured for this purpose only), and 20% L. D. Straight. Others that can be used are Durox, the du Pont Extras, Blasting Powder —and in some instances the du Pont Permissibles, Duobel and Monobel No. 8.

CLAY MINING

For either open or underground clay mining, Durox is recommended. It has low density and high velocity, gives off minimum of fumes, and is economical to use on account of its high cartridge count. Others that can be used are Red Cross Extra, du Pont Extra and Blasting Powder.

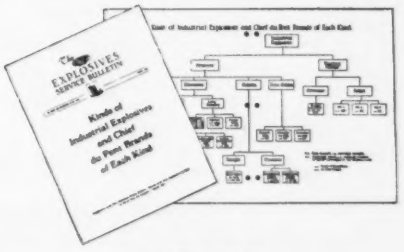
SUBMARINE BLASTING

For this type of work du Pont Gelatin is recommended for first choice; for very hard rock, Blasting Gelatin. In many instances, du Pont Special Gelatin and Quarry Gelatin can be used.



BLASTING ACCESSORIES

To fire the different explosives in the great variety of ways in which they are loaded, requires efficient blasting accessories. The du Pont Company makes a complete line of these. Specify du Pont Blasting Accessories when you order explosives.



· WRITE ·

Write for Explosives Service Bulletin, "Brands of du Pont Explosives and Uses to Which They Are Adapted," giving a list of du Pont Explosives available for efficient and economical blasting operations.

E. I. DU PONT DE NEMOURS & CO., Inc.

Explosives Department • **Wilmington, Delaware**

Pennsylvania Railroad Puts 150 New Electric Locomotives On Timken Bearings

150 of the electric locomotives to be built for the Pennsylvania Railroad's New York-Washington electrification project will be equipped with Timken Bearings on all driving wheels and engine truck axles.

90 of these locomotives will be of the P-5 class, 3,750 H.P., designed for a speed of 90 miles per hour in passenger service. The other 60 will be of the L-6 class, 2,500 H.P., for freight haulage.

The selection of Timken Bearings for this important new equipment foreshadows the universal use of anti-friction bearings on all types of locomotives and railway rolling stock.

This is the largest order for anti-friction bearings ever placed by any railroad at any one time. The Timken Roller Bearing Co., Canton, Ohio.

TIMKEN *Tapered Roller* **BEARINGS**

The
MINING CONGRESS JOURNAL

**A Monthly Magazine—The Spokesman For The Mining Industry—
Published By The American Mining Congress**

VOLUME 17 OCTOBER, 1931 No. 10

Major requirements for stabilizing copper

GENUINE COOPERATION among the producers of the world in the adjustment of supply to demand, and in the reduction and maintenance of stocks at a normal basis.

REVISION of the Anti-Trust laws to an extent that collective curtailment, which is the only effective means for the adjustment of supply to demand, is not only permissible, but encouraged. This revision need apply only when stocks are above normal, and it should be without governmental regulation in any form.

MORE INTENSIVE efforts toward extended and new uses for copper, in alloy with steel and other metals, by metallurgical research.

MARKETING methods that will prevent drastic price fluctuations by the sale or purchase of small amounts of copper.

ORDERLY liquidation of excess inventories.

SALES limited to maximum delivery of 90 days, and by agents financially interested in maintaining prices, and not by dealers and speculators.

CONSOLIDATION of mines into large groups for the reduction of selling and other overhead expenses, and for the acquisition of refining and manufacturing facilities which the individual producer can not afford.

COST REDUCTIONS through improved mining and metallurgical methods, and the recovery and marketing of by-products.

COOPERATION between producers and consumers, with publication or frank interchange of inventory data. This will contribute to stabilization of prices within reasonable maximum and minimum limits, which is beneficial to producer and consumer alike. Both parties are also interested in increasing the uses and markets for copper.

Robt. C. Tally

UNITED VERDE COPPER CO.

Copper and Progress

NATIONAL Industrial Progress and Copper are synonymous. They have gone hand in hand as we have steadily climbed the world's ladder of success. The successful transmission of power is an industrial necessity that copper has made a realty. The copper industry, therefore, in a comparatively short period, has become a national asset to be treated with respect.

According to the last census, in 1929 copper mines numbered 180; they employed 44,493 wage earners, who received a total of $64,849,523 in wages; they bought $57,825,918 worth of equipment and supplies; they paid dividends to their stockholders in the aggregate of more than a hundred million dollars.

No one can successfully predict the future of copper. With electrification of our railroads, the growth of the radio, the scientific studies now but dreams, involving uses of copper, all point to a future comparable with the marvelous development of the past 20 years. With unlimited copper reserves, the United States seems assured of maintaining its supremacy in industrial progress. Certainly the Government should look with favor upon the efforts of the copper producers to curtail production to meet the present situation, and should give every cooperation to the proposed remedies for the industry as presented in this issue by Mr. Robert E. Tally.

Problems of Mining Industry

REGARDLESS of our protests, we have gradually developed through our Government system a machine which is working, frequently constructively and as frequently destructively, in behalf of industry. Whether we like it or not, Washington has a finger in our industrial pie. It has retained in large measure the autocratic powers given it during the World War and is today, through various bureaus, commissions and committees involved in industry's affairs. How to extricate industry from this situation, how to save the good and eliminate the bad in the system is a problem of no small proportions, and one constantly receiving more and more attention.

While industry worries, Washington goes on. It transacts the gigantic business of government, which, because of legislative authority, compels industry to acquiesce in many things it disapproves. A commission is appointed by Congress to "study" this or that situation; a committee is appointed to "report to the President"; a bureau is created that eventually becomes more and more autocratic and less and less cooperative.

Mining is intricately involved in all of this business of government. Let us consider just a few of the industry's major troubles which involve Washington: taxation . . . the remedy for the silver industry . . . stabilization of production . . . maintenance of the protective tariff . . . freight rates . . . congressional and national committees conducting investigations into industry's affairs . . . and proposals to put the Government into business.

We are prone to believe that industry's troubles increase with the convening of Congress. Perhaps they do to the extent of threatened legislation, but Washington, in spite of and because of Congress, is in and out of season involved in practically every problem that confronts mining.

Stabilization of Production

MANY plans are being advocated for the stabilization of industry. They all demand a change in the anti-trust laws. All recommend and require legislative action by Congress, and it is interesting to note the gradual trend toward "letting the Government do it."

Practically all of the suggestions involve: (1) Revision of the anti-trust laws; (2) Employer responsibility; (3) Security of employment; (4) Unemployment insurance; (5) Old-age pensions; (6) Labor relations, involving union labor; (7) Consolidation of enterprises; and (8) Cooperative and combined selling agencies.

During the past month we have had proposals for industry's stabilization from the Law, as exemplified by the American Bar Association; from Industry, as represented by the president of one of its great units, The General Electric Company; from Labor, as represented by the American Federation of Labor. Bankers, economists, the Church, and leaders in most every school of thought have made "recommendations." Late in October New York University will attempt to bring many of these plans together for discussion and clarification.

While all this stupendous recommending goes on, industry, for whose benefit the proposals are being made, has had little to say. Here and there a coal man, a copper man, a silver man, gives vent to his views, but these can in no sense be accepted as the agreement of the great natural resource industries. When all of these units of a gigantic industry finally get together, when they join hands in an effort to solve their problem, when some basic platform can hold them all in agreement—then, and not until then, will the mining industry be on its way to stabilized production.

The Way Out for Mining

DEAN FRANK H. PROBERT, of the University of California, in an address before the Western Division of The American Mining Congress on Stabilizing Natural Resource Industries, urged these industries to free themselves from Government interference and to get hold of their bootstraps for the long hard pull. Most eloquently the Dean pled the cause of humanity and the need for understanding and the elimination of selfishness and greed. He urged the Government to stick to its job of arbiter in public relationships, and industry to accept its responsibility to the public, to the Government and to itself. He advocated industrial planning, which shall have the support and cooperation of Government, and that scientific analytical thought shall be given to problems of distribution and marketing. He urged every consideration for the working man, and the necessity for the people to work out their own problems. He gave as a major factor in our difficulties the fear of Government competition with industry, saying:

"The spectre of Government control or competition hovers over American business, and the hesitancy and timidity which it engenders is a loss to industrial progress. This is not a weakling country needing the succor and care of a bureaucratic wet nurse, yet regulation, restriction, and prohibition of all our acts engage the attention of meddlesome inquisitors. It costs a lot of money to maintain these Federal and State institutions and settle the bills for their mistakes."

Many will agree with these views. The real problem is to make them effective. Industry without leadership is helpless, and almost all industry has stood still for the past few years, apparently awaiting the arrival of a Moses.

Dean Probert's proposals require the same preliminary medicine—revision of the anti-trust laws. Opinion on this one phase seems fairly well clarified. Almost unanimous agreement is found upon this necessity. The next step seems to be a leader with sufficient force and vision to advance a legislative proposal that will give industry what it needs without jeopardizing the protection afforded the public by the anti-trust laws. The task deserves the best brains of industry and the cooperation of the Government.

One Idea of Stabilized Industry

WHILE Mr. Gerard Swope's plan for stabilization of industry relates primarily to industry of the type with which he is so competently identified, its recommendations cover such a vast amount of territory that the mining industry may well take it under consideration.

When the full purport of Mr. Swope's recommendations becomes apparent, it is amazing to find that he has advocated that industry shall place itself in the hands of the Government and under the supervision of the Federal Trade Commission, or some similar agency which is empowered to say "you may, and you may not." As if such a handicap were not enough, he advocates a super-controlling body, composed of a trade association for each industry, which carries out the edicts of the Government in behalf of the industry under direction.

There are many good things in the plan as presented. It certainly is one of the most constructive so far offered. It takes full cognizance of the problems facing industry today through unemployment and insists that industry shall care for those whom it employs. We are in sympathy with many of the recommendations, but we can not join Mr. Swope in any plan which will give the Government complete or remote control over industry, other than regulatory supervision.

Taxing Our Way Out

THE utterances of congressional leaders leave little doubt that hundreds of bills will be introduced in the next Congress, designed to meet our emergencies of depression and unemployment, through taxation. The proposals already advanced include a sales tax of one-half cent on every sale; increase in corporation tax; abolition of capital gains and capital loss tax; increase of surtax on large incomes; reduction of personal exemption; and the broadening of the entire tax plan to include more people. On all of these proposals, except that of the sales tax, a specific increase on the present rate is requested. The Joint Congressional Committee on Tax Legislation is investigating depletion and is expected to make its report shortly after Congress convenes. The research of the staff of the Joint Committee, now under way for approximately four years, has brought forth the Preliminary Report on Depletion, published in 1929, and an additional report is expected late this year.

The mining industry is gravely involved in all of these matters. The industry should be fully informed upon the subject and should so organize itself that with a united front it can meet the assaults that undoubtedly will be directed toward it.

What Is Money

MONEY is the common denominator of business transactions. It is the measure of values and as such must have a stable and uniform value. Since the beginning of time and until the last half century gold and silver has served as money at certain more or less uniform relations. Real money and credit money have a fixed relation during times of universal confidence in the business world but whenever business confidence is questioned or destroyed the real money goes into hiding, the credit money loses its potency and either a panic or a severe business depression results.

Whenever the credit money fails to perform the function of real money the lack of sufficient real money with which to transact the business of the world becomes immediately apparent. If there is a remedy for conditions which now prevail in the business world it would seem to be the establishment of real money in sufficient volume to meet the demands of trade and the limitation of credit money to a proper relation with the real wealth as measured by the real money medium.

It is frequently stated that one dollar of real money can be made the basis of $17 of credit. Probably during the price peak of 1929 the credit transactions were far in excess of this ratio but it would seem that the peaks and the valleys could be better equalized, that a variable ratio properly recorded could be fixed between the credit money and the metallic money which is the support and guarantee of ultimate payment.

Gold

FOR the first time in history the monetary gold stock in the United States has reached the five-billion mark or approximately one-half of the monetary gold reserves of the world. By the prices which have been in operation during the last few years it might easily be possible for France and the United States to practically absorb the total world reserves.

We might well inquire as to what the value of gold would be under such conditions: two countries of the world with ability to purchase from each other, with all other countries forced to develop a new money medium with which to carry on their business transactions. Gold under those conditions would cease to be a universal medium of exchange and lacking that universality would lose its value. Some other metal or some other means of exchange would of necessity be developed by other nations for the carrying on of their own transactions which medium of exchange might have and might not have any value in those countries holding the world's gold supply.

Gold has been regarded as a stable money medium accepted throughout the world, theoretically because it had intrinsic value. Would not gold lose all of its value intrinsic or otherwise if it were so concentrated? The maldistribution of the worlds' gold supply presents one of the serious problems in the industrial world and it is only because of the fact that the possibility of its further concentration is doubted that bankers and financial leaders do not regard this tendency as one of the greatest dangers to our industrial life.

The Cost of Machinery

THE Department of Commerce has issued a report showing the quantity of machinery and equipment purchased and the fuel and electric energy consumed by the 39 branches of the mining and quarrying industry in 1929 as compared with 1919. The cost of machinery and equipment purchased in 1929 by mining companies was $84,506,000, this being the first census year for which data of this type was secured. The largest amount, $34,947,000, constituted machinery and equipment purchases by the bituminous mining industry, followed by other large purchases by branches of mining as follows: $13,084,000, copper mining; $7,174,000, sand and gravel; $5,669,000, limestone; $5,580,000, anthracite; $3,594,000, iron ore; $1,904,000, lead; $1,848,000, zinc; $1,634,000, sulphur and pyrites; and $1,085,000, by the lode gold industry. Equipment purchases by the other branches of mining were less than a million dollars each. The equipment figures do not include installation costs, outlays for parts, repairs, overhauling, supply, etc., nor construction costs for buildings, etc., but are for the purchase of machinery and other equipment only. Mining companies in the following states made the largest purchases of machinery and equipment: Pennsylvania, $15,801,000; West Virginia, $8,272,000; Illinois, $8,240,000; Arizona, $7,248,000; and Utah, $4,063,000.

In 1929 the mining industry consumed 5,223,195 tons of anthracite as compared with 8,697,365 tons in 1919; 8,825,007 tons of bituminous as against 16,208,535 tons 10 years before; 136,896 tons of coke as compared to 53,795 tons in 1919; 169,898,843 gallons of fuel oil as against 152,830,986 in 1919; 16,546,867 gallons of kerosene as compared with 4,113,438 gallons in 1919; and 25,531,295 thousand cubic feet of natural gas as against 2,818,454 thousand cubic feet in 1919. In 1929 the mining industry purchased 5,479,714 thousands of kilowatt hours of electricity and generated in its own plants an additional 2,080,612 thousands of kilowatt hours, the first time figures of this kind were taken in the census, although the department estimates that the 1929 consumption of electrical energy in the mining industry was three times greater than that in 1919.

Getting Talked About

COAL has a positive genius for attracting to itself unfavorable comment. In a multitude of virtues, only the weaknesses are dealt upon. Coal is "poorly managed." Coal is a "bankrupt industry." Coal is a "disgrace to the industrial family." Coal is this and that and the other thing—all uncomplimentary.

We will have to admit all THAT; but hoisting coal's banner high, we venture to point out that coal is the backbone and basis of our industrial life; it is the father of (it is said) some 500 healthy industrial children, all contributing to our happiness, comfort and wealth. In its crude form it furnishes employment to 601,235 workers; it represents 28 percent of the total freight handled by our railroads; it is power, progress and prosperity.

Knocked flat on its back by the world economic crisis, this great industry has begun a successful fight to regain its lost markets, to adjust its labor problems, to conduct intensive research into new uses for its product. Coal may justify the criticism levelled at it, but it is also entitled to its modicum of praise. Like a good man—"Coal may be down but its never out"—and we feel safe in predicting a brighter future. However our prediction is confined to "The New Coal"—with cutting machines replacing the pick—power drills replacing hand augurs—loading machines replacing the shovel—locomotives replacing the mule—mechanical cleaning replacing hand picking—and automatic stokers replacing hand firing. This new coal, completely modernized, through its efficiency, convenience, and economy will take its rightful place in our industrial system.

Our Pet Topic

COUNT that day lost that does not find some recommendation about ending the "depression." This word has had an increasing popularity in our vocabulary. This, in itself, has had its own depressing effect. Rapidly approaching, as we are, another "presidential year," we may expect to hear this term with increasing repetition, so perhaps it is well for us to observe whether we are alone in our misery. Apparently we are not. The *Mid-West Review* sums it up this way:

"This panic is world wide!

"It is in free trade England and tariff United States.

"Agricultural South America and industrial North America.

"Wet Canada and dry United States.

"It is in the countries on a gold standard and on a silver standard, in countries that use machinery and those that don't, in the nations that won the war, that lost the war, and that stayed out of the war.

"It is everywhere, under all kinds of governments, all varieties of civilizations, and all kinds of political and economic conditions."

We can not do much about it by talking. And we might profitably adopt a new national word something like—Progress—for instance.

Russia and American Mining

WE recently presented an engineer's viewpoint on Communistic Russia. It met with greatly deserved popularity. The demand for it taxed our capacity to fill. Apparently the mining industry is in accord with Mr. Grady, the author of the article. More interesting than the article, itself, is perhaps the fact that it has greatly agitated Communism's defenders in this country. We are urged from certain sources, camouflaged and otherwise, to present the "real" Russia, which is said to have abandoned Communism in favor of the Capitalistic system!

Our interest in Russia is confined to her attacks upon the mining industry of the United States; to her repeated and continued efforts to make the most of our unemployment situation; to her desire to turn the great army of mine workers into a Red Army of Russia. Our Journal is frankly partisan to the mining industry. Its function is not to meddle in, or comment upon Russian government. Let that be what they make it. It is only when Russian government attempts, through our industry, to foist her views upon America that our interest is aroused.

Aerial View of the United Verde Workings, Jerome

THE COPPER INDUSTRY

By
Robert E. Tally*

Ransome, U. S. Geological Survey

Plant of the Miami Copper Company

THE position of copper is similar not only to that of the other natural resource industries but to industry and business in general. The copper market fluctuates as business in general fluctuates, and no material increase in consumption is expected until general business conditions improve.

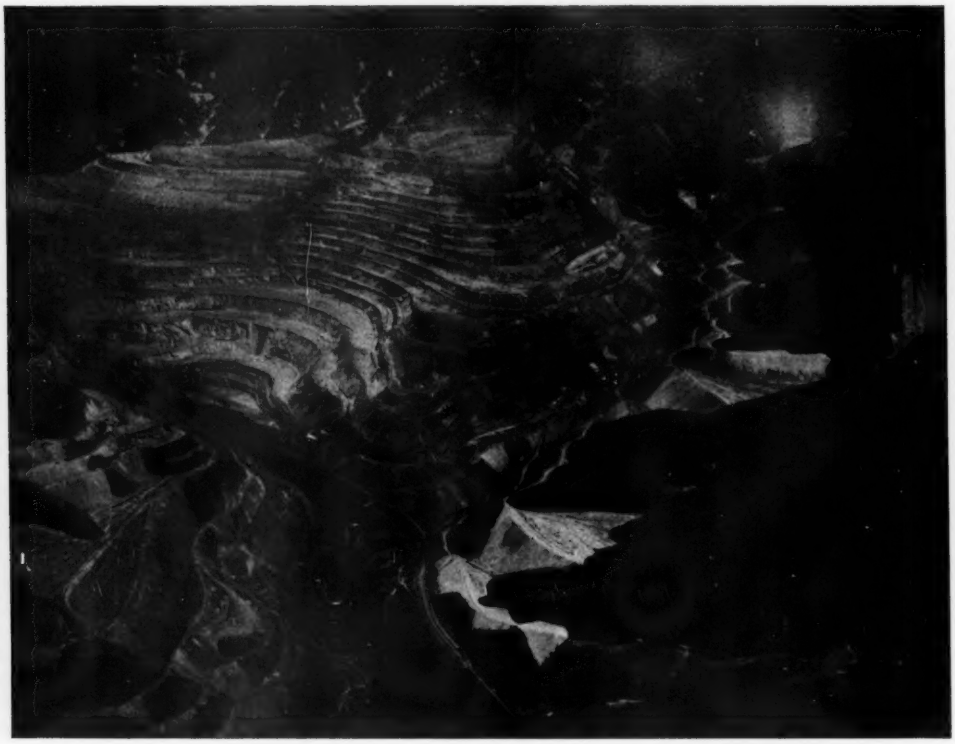
The copper industry is over-developed and while consumption during the present century has increased at an average annual rate of 4½ percent, it is doubtful if demand for the next decade will equalize potential productive possibilities. This is because improved mining and metallurgical methods and the advent of new mines to the producing stage have shown more progress than research in finding new uses and markets for the metal. However, a well-directed and aggressive research campaign should correct this situation, and such a campaign has been started.

The present demoralized condition of the industry is due primarily to reduced consumption, a direct result of the world-wide business depression, and to the inability of the industry to more promptly adjust supply to demand. This has resulted in the accumulation of large inventories, which must be reduced to normal or pooled for orderly liquidation in the export market before any degree of stability can be attained.

Over-production or under-consumption and disorderly marketing methods are recognized as the two major problems of the industry, and the ideal solution of these problems is the adjustment of supply to demand and the reduction to and maintenance of stocks at a normal basis.

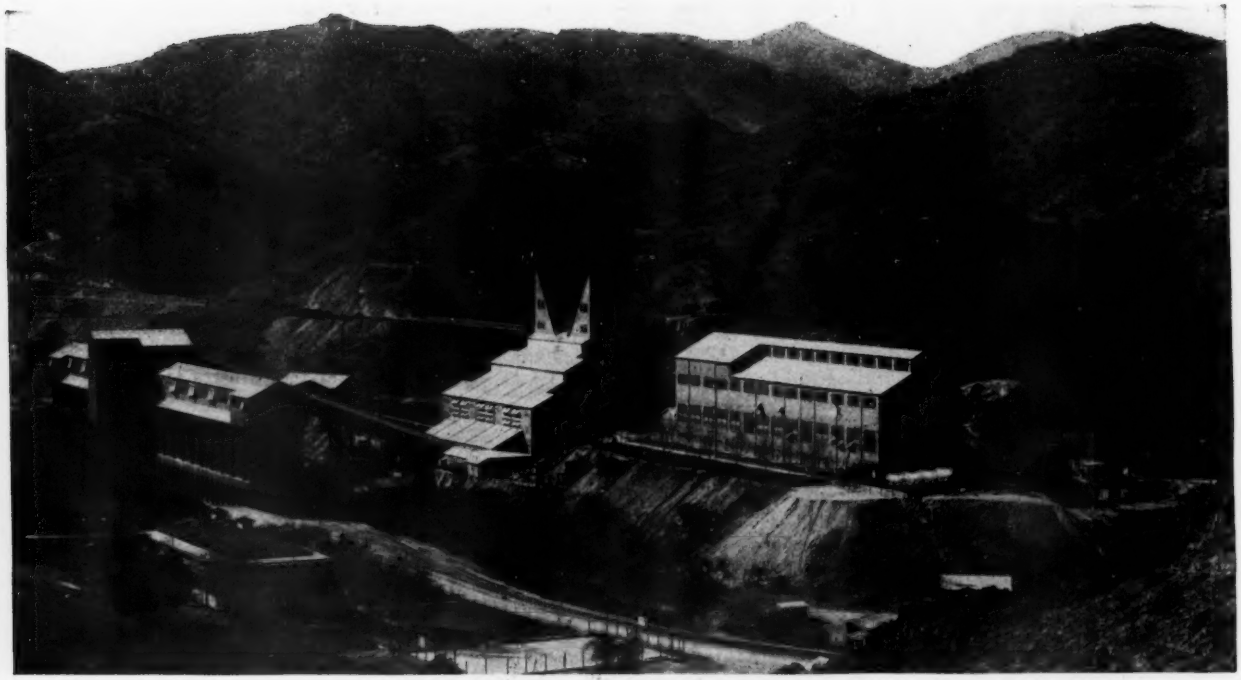
The marketing of copper is not a seri-

* United Verde Copper Co.

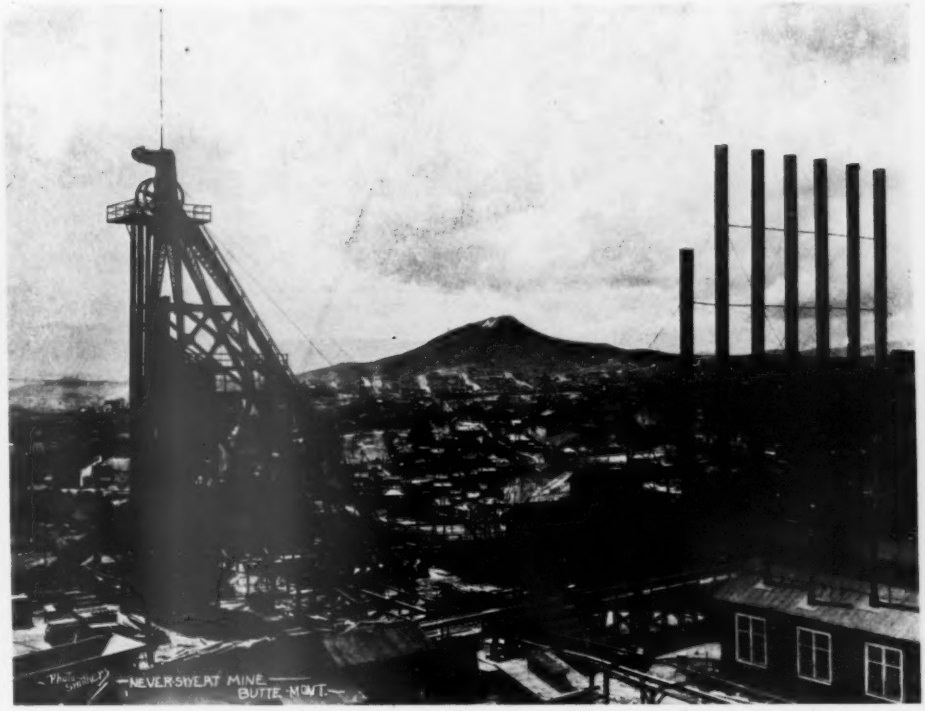


An airplane view of the workings at Bingham Canyon of the Utah Copper Company

©Aerograph Co., Oakland, Calif.



Main Shaft, Inspiration Consolidated Copper Company



Never-Sweat mine of the Anaconda Copper Company

ous problem when stocks are at or below normal, and it is only during the period of excessive inventories that unsound marketing becomes troublesome. However, this is the condition under which the industry is now laboring, and which is responsible for the prevailing instability of the copper market.

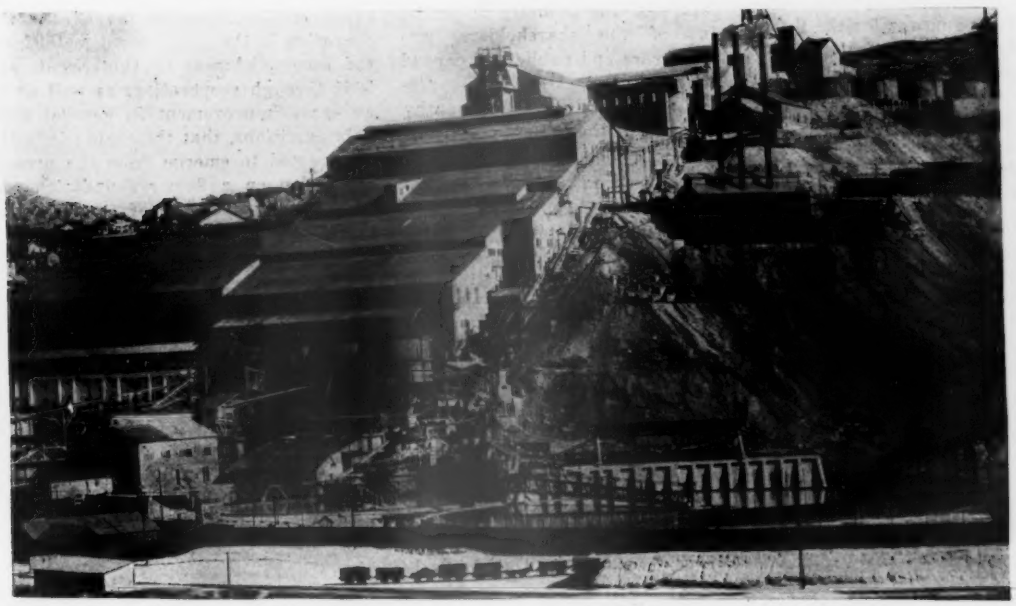
Excess production is the natural result of an overdeveloped industry, and large inventories, with low metal prices, are the penalty. The final result of this condition, if not corrected, is wage reductions, closing down of mines, and general demoralization of the industry.

The operation of a mine, or of a mining company consisting of a group of mines, is always more satisfactory from the standpoint of costs and otherwise when the operations are at or near capacity, and the individual producer that curtails is at a disadvantage with competitors, and does not materially help the situation unless the curtailment is general and of sufficient extent to be effective.

The history of the copper industry has been one of peaks and depressions. Mines have been depleted without uniformly attractive returns to the shareholders; wages have been unstable, and employment uncertain.

From the standpoint of efficiency, the technical, operating and executive branches of the copper industry compare favorably with those of any business, but progress in marketing and economics has not been satisfactory. This condition is characteristic of many industries, if not of business in general. The reasons are obvious. In individual cases progress is the result of the coordinated efforts of a specific mining organization, while the industry, with its competitive features, its anti-trust law restrictions, and its lack of necessary confidence and cooperation among its members, is in an atmosphere not particularly favorable to the development of progress.

However, the situation as regards copper is not hopeless. It is disappointing but not discouraging. Considerable progress has been made toward a general curtailment plan, but the extent of the curtailment is not impressive, and no provisions have been made for the orderly liquidation of the excess inventories, or for the correction of other weaknesses,



Concentrating Mill, Morenci Branch, Phelps Dodge Corporation, at Morenci, Arizona

Chino mine of Nevada Consolidated Copper Company

essential to a successful stabilization plan.

Inventories should show a moderate reduction under the proposed curtailment plan if the present rate of consumption continues, but prevailing business conditions require a more positive plan, one that will provide for further curtailment, if necessary; for the systematic disposal of stocks, and for more flexible and modern methods of doing business by the custom smelters. If business does not improve, and if further adjustments within the industry are not expedited, wage reductions, with temporary and partial suspension of operations, are probable.

The major requirements for stabilizing copper are:

(1) Genuine cooperation among the producers of the world in the adjustment of supply to demand, and in the reduction and maintenance of stocks at a normal basis.

(2) Revision of the anti-trust laws to an extent that collective curtailment, which is the only effective means for the adjustment of supply to demand, is not only permissible, but encouraged. This revision need apply only when stocks are above normal, and it should be without governmental regulation in any form.

(3) More intensive efforts toward extended and new uses for copper, in alloy with steel and other metals, by metallurgical research.

(4) Marketing methods that will prevent drastic price fluctuations by the sale or purchase of small amounts of copper.

(5) Orderly liquidation of excess inventories.

(6) Sales limited to maximum delivery of 90 days, and by agents financially interested in maintaining prices, and not by dealers and speculators.

(7) Consolidation of mines into large groups for the reduction of selling and other overhead expenses, and for the acquisition of refining and manufacturing facilities which the individual producer can not afford.

(8) Cost reductions through improved mining and metallurgical methods, and the recovery and marketing of by-products.

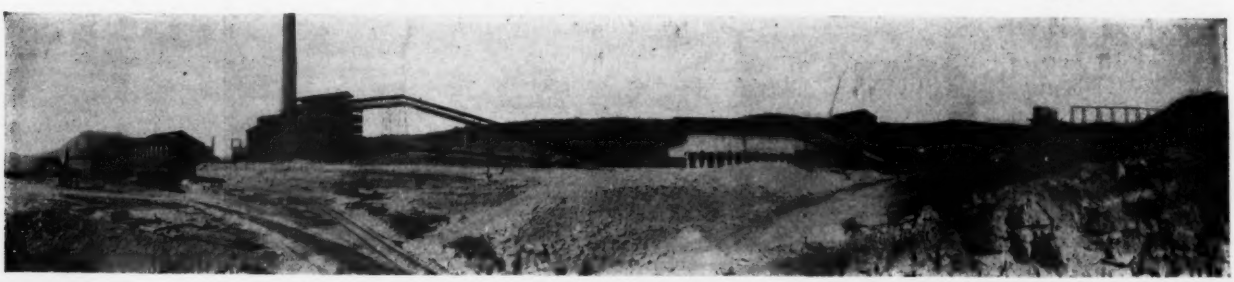
(9) Cooperation between producers and consumers, with publication or frank interchange of inventory data. This will contribute to stabilization of prices within reasonable maximum and minimum limits, which is beneficial to producer and consumer alike. Both parties are also interested in increasing the uses and markets for copper.

The future of the industry from the standpoint of the shareholders, employes, consumers and public will depend on the character and extent of cooperation among producers, and the sympathy and cooperation of the Government.

Cooperation among producers in the past has not been whole-hearted or effective. However, the recent curtailment showed a splendid spirit of cooperation and, if this is continued and extended and reinforced in its lines of weakness, the copper industry will not only weather the present storm, without further disorders, but will stand on a firm foundation; a foundation of confidence, which is the keystone to any successful stabilization plan.

The history of national and international business shows that depressions have occurred periodically. They are interwoven with and a part of the natural law of economics. The business structure of the world is so inter-related and of such a complex nature that their prevention is most difficult, if not impossible. Economists consider them corrective measures from which properly conducted business eventually emerges and becomes stronger and better than before. Inflation is the usual and direct cause of depressions and, likewise, can not be prevented or controlled. However, the result of a depression is so far-reaching and of such a serious nature that every reasonable effort should be made to reduce, if not to remove, the cause and to minimize the effect. Cooperation is the only known method for the accomplishment of this result, and it is through cooperation, as well as by an early improvement in general business conditions, that the copper industry is expected to emerge from the present depression on a firmer foundation and with a greater degree of stability than heretofore known by the industry.

Smelter of the Magma Copper Co.



Review of the

Copper and Brass Research Association

By R. L. Agassiz*

IN 1919 when the United States began to relax from the intensive production stimulated by war activities and industry generally turned to normal markets for consumption of its output, it was found in some cases that these markets were almost non-existent. For example, munition requirements had so completely absorbed copper production, even when greatly expanded, that during the war years substitutes for copper and its alloys had come into wide use.

The sudden termination of the war left the copper industry with tremendously expanded facilities and large reserve stocks. In addition the Government had large quantities of copper for release in the market; but because of substitutes the usual market for the metal had largely passed out of the picture.

Obviously, the copper industry faced a crisis. Something had to be done, and done expeditiously, to restore copper to its place in commerce. It was a question of doing even more than that. With the industry stimulated to a very high productive capacity, expansion of uses and new outlets for copper were required. The situation was carefully and thoroughly surveyed by the industry and disclosed a rather discouraging outlook. Copper's place had been preempted in so many fields that to find a starting point for a campaign of restoration was in itself a problem; but copper has qualities that gave encouragement. The industry realized that lasting service, proved by centuries of use, made copper without a real rival in many fields where substitutes had gained a foothold. Therefore it was decided as a part of a campaign to take the story of copper's service directly to the American people. The Copper and Brass Research Association was organized with that objective as part of its program.

The accomplishments of the Association, with the cooperation of various units of the industry, in educational and promotional work for copper have been most gratifying. No one had supposed, prior to 1920, that such utilitarian materials as metal pipe and sheet could be made to have absorbing interest for the American public. They had been advertised, of course, to the plumber and sheet metal worker, but mainly in a conventional way. No one had gone to the people with them. Romantic and historic interests were woven around them, together with reasons for their personal interest to everyone who owned a home or building, when the Copper and Brass Research Association undertook educational work for copper and its alloys. Brass pipe for water supply lines in buildings was either not considered at all or regarded as being something of a luxury at that time. About 2,000,000 pounds was all that was being consumed annually by the construction industry.

Promotional work by the Association, supported later by campaigns of the individual member companies, soon produced a widespread brass-pipe consciousness based on recognition of the superior serviceability and ultimate economy of the pipe. Its use increased about forty-fold by 1929. This is also true of copper sheet metal work in building construction. The public is so interested today in copper and brass that builders use as a strong selling point the fact that their houses have copper flashings, gutters and downspouts and brass or copper plumbing.

Public good-will for copper products has the support too of trade and professional good-will. The Association, as part of its activities, has cooperated extensively with architects, builders, plumbers and sheet metal trades. The endeavor in that direction has been to assist in proper application of copper and its alloys, to indicate possible extension of present uses of the metals and also to point the way to new uses.

Just now the architectural profession of this country is much interested in the use of metal for vertical surfaces. There is a belief expressed by many prominent architects that the day of heavy masonry walls for buildings is passing. The steel framework of modern buildings relieves the walls of the burdens they once carried. More and more they are being regarded in the nature of "curtains" or enclosing surfaces. The Association has been active in demonstrating to the architectural profession the practicability of the use of copper for walls. Much has been done abroad, particularly in Germany, in this new and modern use of copper. The Association has issued brochures and booklets informative to architects concerning the foreign success with copper for vertical surfaces. Naturally this would be a very important extension to present conventional uses of sheet copper should the employment of metal walls begin to progress as rapidly here as it has done abroad in the past two years. This development is emphasized to indicate how an Association such as this can do valuable pioneering work for the industry it represents.

While endeavoring to promote new uses for copper products, the Association does not, of course, neglect the familiar markets. It is constantly at work cooperating with industrial users of copper products in order that they may more fully understand and avail themselves of the services of these metals.

The research work of the Association includes surveys of various industries through which the copper industry is kept informed of all industrial uses of its product and advised of ways and means by which the most effective cooperation can be given to the users of copper products.

Through its advertising and general educational work, its cooperation with trades and professions in technical matters and its research work, the Association is rendering very important service to the copper industry. At the same time it is demonstrating that a trade association can be of very considerable service to the public, which, after all, is equally as important as being of service to its own industry.

* President, Copper and Brass Research Association. Chairman of the Board, Calumet & Hecla Consolidated Copper Company.

Fort Wilkins, Copper Harbor, 1850

HISTORICAL SKETCH *of the* Lake Superior Copper District

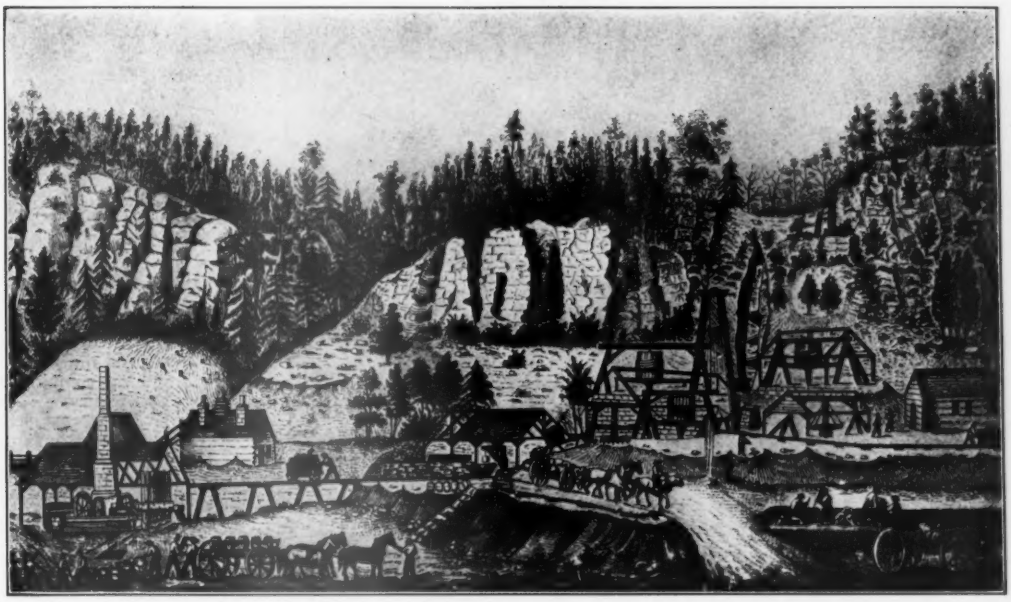
THE Lake Superior District is the only place in the world where native copper has been found in any considerable quantity, and there is probably no more conjecture involved in assuming that the copper used by the ancient Egyptians came from this region than in assuming that these ancients were sufficiently advanced in the science of metallurgy to reduce the metal from its ores thousands of years before Christ.

However that may be, the evidences of the mining of copper in Michigan go back to the prehistoric time when a race of intelligent men of whom we have but little knowledge mined this metal with some system on Isle Royale and Keweenaw Point. In the pits that they dug have been found masses of metal, some of enormous weight, accompanied by crude implements of stone and copper. Many of the Lake Superior beds were mined to a shallow depth for mass copper by this long-gone race. That they were good judges of mineral values has been proved by the making of good modern mines under many of these ancient pits.

The first printed narratives regarding this district are sometimes marred by a variety of fairy tales embellished with many statements not warranted by the facts—statements that are amusing and amazing, but quite impossible. The first written account of the existence of native copper on the southern shore of Lake Superior is found in a book by Lagarde, published in Paris in 1636. He tells of the copper, gold, diamonds, "steel" and certain blue, transparent stones which are more valuable than turquoise, all to be had in this section for the mere labor of picking them up. The Jesuit Relacions for 1659 and 1660, and several other publications prior to 1750, speak of the masses of copper found in this region and refer especially to the historic "Ontonagon Boulder," a mass of pure copper weighing nearly two tons that lay exposed for unknown ages on the bank of the Ontonagon River, where it was worshipped by the natives and held in veneration as an unusual work of their "Gitchie Manitou."

The first tangible proof of the existence of native copper in the Keweenaw Peninsula came when the Jesuit missionary, Claude Allouez, brought back to Quebec in 1666 specimens of solid copper found on the south shore of Lake Superior. To Father Allouez should go the credit for being the first white man who, of a certainty, saw copper in the now famed "Copper Country."

In 1763 and for several years following, Alexander Henry, an adventurous Englishman who was in turn hunter, explorer and miner, spent considerable time in this region, having come here soon after the conquest of Canada by the British. During the year 1765-1766 he was occupied in coasting along the shores of Lake Superior looking for mineral treasure and in the course of his voyage visited the mouth of the Ontonagon River. He writes, "I found this river chiefly remarkable for the abundance of virgin copper which is on its banks and in its neighborhood. The copper presented itself to the eye in masses of various weight. The Indians showed me some of twenty pounds. They



Cliff Mine
1850

By James Fisher*

were used to manufacture this metal into spoons and bracelets for themselves. In the perfect state in which they found it, it required nothing but to beat it into shape . . . On my way back to Michilimackinac I encamped a second time at the mouth of the Ontonagon River and now took opportunity of going ten miles up the river with Indian guides. The object for which I more expressly went, and to which I had the satisfaction of being led, was a mass of copper of a weight, according to my estimate, of no less than five tons. Such was its pure and malleable state that, with an axe, I was able to cut off a portion weighing a hundred pounds."

During the succeeding 75 years many explorers and scientists followed Henry's example and the boulder became well known as a mineralogical curiosity. In 1843 it was transported by James K. Paull on a low truck with line and capstan nearly three miles through a dense wood with numerous hills and valleys to the main Ontonagon River, and was floated on a bateau to the mouth. The Government, however, claimed ownership of the specimen and Major Cunningham, officer in charge of Fort Wilkins at Copper Harbor, was instructed by the Secretary of War to secure the boulder and bring it to Washington. For a brief period it was placed on exhibition at Detroit; toward the end of 1843 it was brought to Washington and deposited in the yard of the Quartermaster's Bureau of the War Department. There it remained until 1869; it was then transferred to the Smithsonian Institution where it now rests.

During the winter of 1771-1772 an adit was driven about 40 ft. into a clay bank of the Ontonagon River near the present site of the Victoria dam. While the men were working in winter no support was necessary for the frozen clay, but the spring thaw brought their operations to a stop. Thus ended the first "mining" operations by white men in the Lake Superior District, just at the time that they supposed and hoped they were about to come upon a solid vein of copper, but in reality just before they reached the red sandstone. No further attempts at copper mining were made in the district for about 70 years.

The Treaty of Paris in 1763 transferred the control of what is now the Upper Peninsula of Michigan from the French to the British. After the close of the Revolutionary War the treaty of peace of November, 1782, made Michigan a part of the United States. The final treaty of September, 1783, established the boundary line between the possessions of Great Britain and those of the United States. This line ran through the middle of Lakes Ontario, Erie and Huron and their connecting waterways. Benjamin Franklin, a member of the boundary commission who had heard of the mineral wealth of Lake Superior, deflected his pencil, upon the crude map that was made the basis of delimitation, to the north of the middle line passing through Lake Superior, thereby including Isle Royale as a possession of the United States. Because of long and vexatious delays in communication and the reluctance of the British military contingent to turn over its authority, the United States sovereignty was not established over Michigan for a number of years. It was August, 1796, before the British flag gave place to that of the United States at Michilimackinac, the military headquarters of the Upper Peninsula.

On May 24, 1820, General Cass, who had been governor of the Territory of Michigan since his appointment in 1813, set out with a well-selected party on his important expedition of exploration, the itinerary including the southern shore of Lake Superior. There was considerable conjecture regarding the existence of copper, and in a less degree of other minerals; and it was among the chief objects of this expedition to make, as far as possible, geological and mineralogical investigations. Henry R. Schoolcraft, the topographer and mineralogist of the expedition, reports that in their journey along the south shore of Lake Superior the explorers frequently found specimens of copper. The party passed through Portage Lake and thence up to the mouth of the Ontonagon River, which they ascended to view the then celebrated "copper rock" that lay upon its banks.

In 1830, Schoolcraft organized an expedition for the discovery of the sources of the Mississippi River. This expedition, whose itinerary included the south shore of Lake Superior, had as one of its members Doctor Douglass Houghton. Doctor Houghton was, at the time of his appointment, a physician in Detroit. He was a keen observer, much interested in science, and a valuable member of the party as surgeon and botanist. Thus began the career of Douglass Houghton in this section where he was destined to render service of incalculable value. To him, more than to any other man, must

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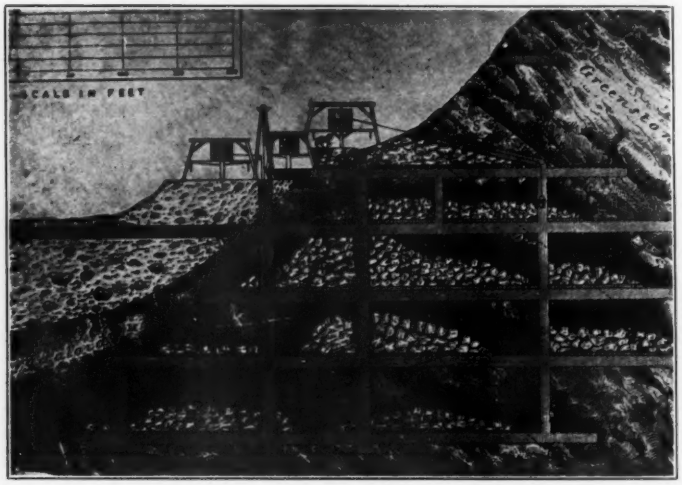


Section of Cliff Mine—1850

be given the credit for the early and rapid development of the copper industry.

On the admission of Michigan into the Union as a state in 1837, the first governor, Stevens T. Mason, recommended a geological survey for the state and appointed Doctor Douglass Houghton as first state geologist. Doctor Houghton's report, submitted to the legislature on February 1, 1841, furnished the first definite information relative to the occurrence of native copper on Lake Superior. He saw very clearly the future importance of its mineral wealth, but was extremely cautious in his statements. He said, "The earliest, as well as all other travelers who have visited the district under consideration, have not failed to make frequent allusion to the loose masses of native copper that have been occasionally found scattered over it, nor has anyone failed to allude to the large boulder or loose mass of that metal upon the Ontonagon River. Almost invariably the opinion has been expressed, from the frequent occurrence of these masses, that the metal must be abundant in the country. But, after all, the true sources from which these masses had their origin, or the relation which they held to the rocks of the district, would appear never to have been understood, and all or nearly all that was known of their true relations was left to conjecture. The result of this has been that while some have excessively magnified everything connected with the subject of which, in truth, nothing was known, another class, equally far from what is really true, have regarded these masses of native copper as boulders transported from high northern latitudes."

The report of 1841 was the last made by Doctor Houghton to the legislature, the poverty of resources of the young state having compelled a suspension of the survey. In 1844 he entered into a contract with the Federal Government to complete the linear survey of the Upper Peninsula, then in progress, and to combine with it a thorough geological, mineralogical, topographical and magnetic survey. Excellent progress had been made in this work during 1844 and until the untimely death of Doctor Houghton who was drowned near Eagle River, October 13, 1845.

The only vein whose location is definitely mentioned in the reports of Doctor Houghton is that of a green silicate of copper at Copper Harbor. It is reasonable to suppose that he knew the location of veins carrying native copper, but the survey had not been completed and the land had not been thrown open for settlement or even for exploration. The reports, however, called attention to the possibilities of the region and numerous applications were made to the War Department for permits to explore for minerals and to locate tracts of land in the district. By a succession of treaties with the United States the Indians relinquished their claims to the lands of the Upper Peninsula, the final treaty being ratified March 12, 1843. This was the signal for starting a wild rush to the district and a speculative craze that lasted for several years.

The Lake Superior district was the first of the great mining regions in the country to be exploited, the first in which was indicated the aptitude of the American for such preliminary work. The fever of exploration on permit culminated in 1848. The population had increased to a point where the true pioneer was beginning to feel that he was but one of a crowd. Rumors of the discovery of gold in California began to arrive, and the Copper Country pioneers formed the nucleus of the California "forty-niners." Since that time every important mining district in the Western Hemisphere has drawn its quota of pioneers from this section.

The first permits granted by the Secretary of War permitted individuals to select a tract three miles square; but this provision was soon modified and only one square mile was allowed. The grantee was required to make a selection within one year, to mark the corners thereof, to have a person in charge to point out the bounds, and to file with the Department a description of his claim. About 1,000 such permits were issued by the War Department; 960 selections were actually made. Sixty leases for tracts of nine square miles and 317 leases for tracts of one mile square were perfected, and mining companies were organized under these leases. Many alleged copper deposits were "located" of which succeeding generations of miners and geologists have been unable to find the slightest trace. Copper was reported to have been found everywhere from the beach along the lake shore back into the forest for as many miles as the prospectors had gone. Before the lands in this region were brought into market the permits issued by the War Department were the only titles which people could obtain to lands, and they were naturally not infrequently rated at a high value. The only persons who really secured substantial profits from many of these mining concessions were those who sold them early at fancy figures.

The first locations made after the treaty with the Indians in 1843 were near Copper Harbor, because of its ready access by water and because of the rock exposures in this neighborhood. Rumors of extraordinary finds were common and eastern capitalists were attracted by the possibilities of the district. Associations of men were formed, leases were purchased, and experienced men were sent to look after further exploratory work.

The Lake Superior Copper Company was the first organized company in the district. As originally constituted on February 22, 1844, it included in its holdings seven of the three-mile-square leases, totaling, after deductions for overlapping claims, over 40 square miles of territory, nearly all of which was situated in the richest portion of the then known mineral region. Several veins were located and work commenced in 1845 on the east bank of Eagle River near the place now known as the Phoenix mine. The lode was represented as of unparalleled richness, the silver far exceeding the copper in value. The first report of the trustees contains a statement of the results of an assay as follows:

In a ton of rock—	
Silver, 152.56 pounds, valued at	$3,053.20
Copper, 203.57 pounds, valued at	83.57
	$3,136.77

These representations contributed toward the creation and maintenance of the copper mania that prevailed for a time throughout the eastern cities. Many were doomed to a speedy and bitter disappointment, but the ultimate effect was to divert capital into a new and untried channel and to develop the mineral

Douglass Houghton

wealth of a region which, but for these representations, might have remained unexplored for a long time.

The Cliff mine was discovered in 1845 by a party of explorers working for the Pittsburgh and Boston Company. Following a narrow vein which outcropped on surface, an adit driven 70 feet into the side of a bluff encountered the first mass of copper ever found by systematic mining. This discovery was of the greatest interest and importance, not only to the company but to the whole mining interest on Lake Superior. It gave encouragement to those engaged in prospecting and induced them to persevere.

The practice, current until the late seventies, of calcining the vein rock before stamping was started at the Cliff mine. The calcining was accomplished by piling the rock upon a layer of crossed cordwood and setting fire to the wood. Sometimes the rock and wood were arranged in alternate layers. After burning for from two to four days, the rock became quite friable, the larger pieces of copper were picked out by hand and the remainder was easily crushed under the small drop stamps then in use. The roasting was performed in the open air, the "kilns" usually being structures of rock built on three sides against a hill. The temperature attained was sufficient to calcine the rock without fusing or appreciably oxidizing the copper. Water was sometimes poured on the heated rock to assist the breaking up process. Because of the low cost of fuel the process was probably an economical one.

The $60,000 paid by the Cliff mine in 1849 was the first dividend earned and paid by any mine in the district. The total amount subsequently paid in dividends by this company was $2,627,000, a little over 2,000 percent of the paid-in capital.

The occurrence of the masses that were found in considerable quantity in fissure veins at the Cliff mine stimulated mining exploration and development in an extraordinary degree, and the attention of explorers and investors was concentrated on finding similar veins. Scores of test pits and trenches were made, but unfortunately in most cases more money was put into them than was ever taken out. One notable exception to this was the discovery of an ancient pit containing a mass of copper in a well-defined vein about seven miles east of the Cliff. This discovery resulted in the organization of the Central Mining Company. During the period of operation, from 1854 to 1898, the Central produced copper and silver that marketed for nearly $10,000,000, nearly $2,000,000 of which was paid in dividends, representing over 2,000 percent of the paid-up stock.

The Minnesota mine in Ontonagon County was opened on a strike fissure in 1849 and paid its first dividend in 1854. What is believed to be the largest complete mass of native copper ever found was discovered in this mine in 1856. This mass was 46 ft. long, its greatest width was 18½ ft., and its greatest thickness 8½ ft. It weighed approximately 500 tons. Twenty men labored 15 months to work around it and dislodge it from the rock. In doing this 2,750 pounds of powder were used. The mass was then cut into pieces small enough to be handled. It netted the company about $150,000.

The Minnesota affords another instance of an extraordinary profit from a small investment. For every dollar paid in before 1876, the mine returned nearly $30 in dividends. No other mine in the country has produced so great an amount of copper for the same amount of labor and capital expended.

Next to Copper Harbor and Ontonagon, the Portage Lake district was most accessible to the early explorer for copper, and during the summers of 1846, 1847, and 1848 this section was explored about as thoroughly as could be expected by individuals, unorganized and handicapped by limited capital. The explorers were looking for rich fissure veins and paid little attention to the amygdaloid beds, even though these were known to contain some copper. The Quincy Mining Company was organized in 1848 and the Pewabic Mining Company in 1853. In 1856, after three years of exploration at the Pewabic location and eight years at the Quincy, the great Pewabic amygdaloid lode was discovered by the Pewabic Company. The Quincy Company promptly followed the lead of the Pewabic, stopped work on the worthless cross-veins and concentrated its efforts on opening up the amygdaloid. These, the first successful mines on an amygdaloid lode, served to divert some of the exploration activities from fissure veins to lodes.

A corporation known as the Ohio and Isle Royale began mining in 1845 on Isle Royale but transferred its base of operations to the south side of Portage Lake in 1852 and discovered the Isle Royale amygdaloid.

For 15 years prospectors made their way overland from Eagle River to Portage Lake, never suspecting the riches of the district through which they traveled—the present site of Calumet. The famous Calumet conglomerate was discovered in 1864 and the Calumet and Hecla mines were opened two years later. Although this is the company most commonly referred to in conversation with visitors or inquirers, it must be recognized that it is not representative of the region as no other mine compares with it either in richness of rock, in amount of production, or in profits.

Space does not permit a reference to all the companies that have operated with more or less success in the district, and in this brief sketch only incidents and properties have been selected that typify the district.

CALUMET AND HECLA CONSOLIDATED COPPER COMPANY

Alexander Agassiz

ALEXANDER AGASSIZ and the early history of the Calumet and Hecla

By George R. Agassiz

THE story of the discovery of the Calumet mine reads more like a page of "Monte Cristo" than a bit of the history of northern Michigan. Piecing together what we now know, we can imagine a party of Indians digging out copper on Isle Royale. As the summer waned, they loaded the spoil in canoes and paddled across Lake Superior to Keweenaw Peninsula, where, overtaken by an early winter storm, they dug a pit, cached their copper, and attempted to escape south.

In 1858 E. J. Hulbert, who was surveying a state road through the primeval forest that then covered the present site of Calumet and the surrounding district, stumbled onto this pit. Mistaking it for an old Indian copper working, he cleaned it out and discovered in the bottom a quantity of weathered copper; but when he had removed this, he was puzzled to find no further traces of copper. Blasting in the bottom of the pit, he uncovered a stratum of copper-bearing rock. *The cache happened to be in the hanging wall* of what was afterward known as the Calumet Conglomerate. Improbable as this seems, Hulbert always insisted that he did not find the copper-bearing stratum until he had blasted. Not far away he found a boulder of the same material that had been heaved up by the frost. Satisfied that he had made an important discovery, he kept his secret to himself, but with his tiny capital he was unable to get possession of the land on which the pit was situated. He eventually bought the adjacent land, but it was not until August, 1864, that he found himself in position to make an opening. Then extending a line from the boulder through the pit to the edge of his property, he sank a shaft there, and by the middle of September he was well into the copper-bearing conglomerate. Hulbert then went to Boston, where Mr. Quincy A. Shaw and his friends bought a controlling interest in the venture. The Calumet Mining Company was formed and Hulbert was given the development of the property. A few months later the same interests bought the land on which the pit was situated, the Hecla Mining Company was organized, and again Hulbert was put in charge.

Hulbert wrote back glowing accounts of his progress at the mines. The lode near the surface was excessively rich, and seeing great masses of copper tangled in the rock he lost his head. He proceeded to quarry out the rock haphazardly from open pits, carted it with teams of horses 13 miles to Hancock, and attempted to smelt it. Such irregular methods were bound to lead to their inevitable results. The hard, tenacious, and finely divided conglomerate proved to be a very difficult thing to mine and mill from any rocks hitherto worked in the district. The best experts of the day declared that the lode could not be operated at a profit, and the enterprise threatened to end disastrously for all involved.

Mr. Shaw's young brother-in-law thought differently, however. Alexander Agassiz had been educated as an engineer, but heredity proved stronger than training. At that time he was an impecunious assistant in the museum of natural history that his father, Louis Agassiz, had founded at Harvard. As a forlorn hope, when things looked very black, young Mr. Agassiz was sent to Calumet to attempt to rescue a desperate venture.

Before leaving he met on the streets of Boston a young instructor at the Massachusetts Institute of Technology, who had rowed with him on the Harvard crew, C. W. Eliot, the future president of Harvard. Agassiz told Eliot that he was going to Michigan to make money if he could in order to be able to continue his scientific life and publish his work. Seldom have the aspirations of youth borne in maturity such abundant fruit.

Mr. Agassiz reached Calumet in March, 1867. The faded pages of a couple of letter books nearly 65 years old give a vivid picture of the gallant struggle of the two brothers-in-law as they strove, against what seemed hopeless odds, to bring order out of chaos. While Mr. Agassiz, with many hands against him as an outsider, and with insufficient means, was struggling to get the mines on their feet, Mr. Shaw, submerged in debt, was straining every nerve to extract funds from a community that had lost confidence in the enterprise. As Mr. Agassiz used to say in after years, "If Quin had ever known when he was beaten, we should never have pulled the thing off"; but pluck, pertinacity, and ability finally won the day.

In less than two years, in what was then virtually a wilderness, Mr. Agassiz rectified the mistakes of his predecessors, built a railroad to Torch Lake, dredged a channel to navigable waters, developed and equipped both mines, including a mill for each, and got the enterprise working smoothly at a profit. By the end of the summer of 1868 the Calumet mine and the Hecla mine were two prosperous little concerns, producing between them about 325 tons of ingot a month. From such small beginnings was launched the industry that afterward became so phenomenally successful.

THE fight won at Calumet, Mr. Agassiz returned to the more congenial career of an investigator of natural history awaiting him at Harvard. This remained his major interest through life; but until his death, for more than 40 years he kept his hand on the direction of affairs at Calumet, going there twice a year, and his scientific expeditions were so planned, with few exceptions, as not to interfere with these visits.

In 1871 the Calumet mine, the Hecla mine, and the Portland and the Scott Mining Companies were consolidated into the Calumet and Hecla Mining Company with Mr. Shaw as its first president. A few months later he retired to the board of directors and Mr. Agassiz became president, a position he held for the rest of his life. Mr. Shaw and Mr. Agassiz directed the company, but as Mr. Shaw was not an engineer the development of the mine fell to Mr. Agassiz.

It was his policy to keep the mine opened up far ahead of the work. This enabled him to see what conditions would be years later and make ready for them well in advance. This was no small factor in the great prosperity of the mine and the scale on which it was possible to operate. He never hesitated to spend money freely for a future return and to build not only for the coming years but for the next generation.

However, the welfare of the employes was his chief care. He saw to it that they were well paid and well housed and were provided with ample opportunities for broader and better lives. Some years ago a governor of Michigan said that Alexander Agassiz had done more in the state than all others for humane and reasonable conditions of life among its working people.

In the park overlooking Calumet, Agassiz's statue by Paul Bartlett, a bronze figure of classic beauty, seated in academic robes, serene, dignified, and tinged with the mystery of death, keeps silent watch over a city hewn from the wilderness by his wisdom and grit. The pedestal bears this inscription:

ALEXANDER AGASSIZ
1835-1910
A MAN OF SCIENCE
WHO
DEVELOPED A GREAT MINE
AND
WROUGHT THE WELFARE OF ITS PEOPLE

HISTORY of the Calumet and HECLA since 1900

By James MacNaughton*

At the beginning of the period covered by this history the Calumet and Hecla mines had been in operation for 34 years, and it was the belief on the part of many that they had passed their productive zenith. Mining on the conglomerate lode had reached an average depth of about 4,000 ft., measured on the slope of the lode, while the average copper recovered had shown a decrease from a high of 96.8 pounds per ton in 1874 to 52.15 pounds per ton in 1900. The lode had increased in thickness and the mineralization was not as concentrated as it was nearer surface. Furthermore, with greater depth there was increasing pressure from the hanging-wall which necessitated more extensive timbering. All of these adverse conditions tended to increase the cost per pound of copper. The Osceola amygdaloid lode, which is about 700 ft. east of, and parallel to the conglomerate, also crossing the mine property, had been opened to a considerable extent and some stope mining done, but because of its low copper content had been closed down in the belief it could not be mined profitably.

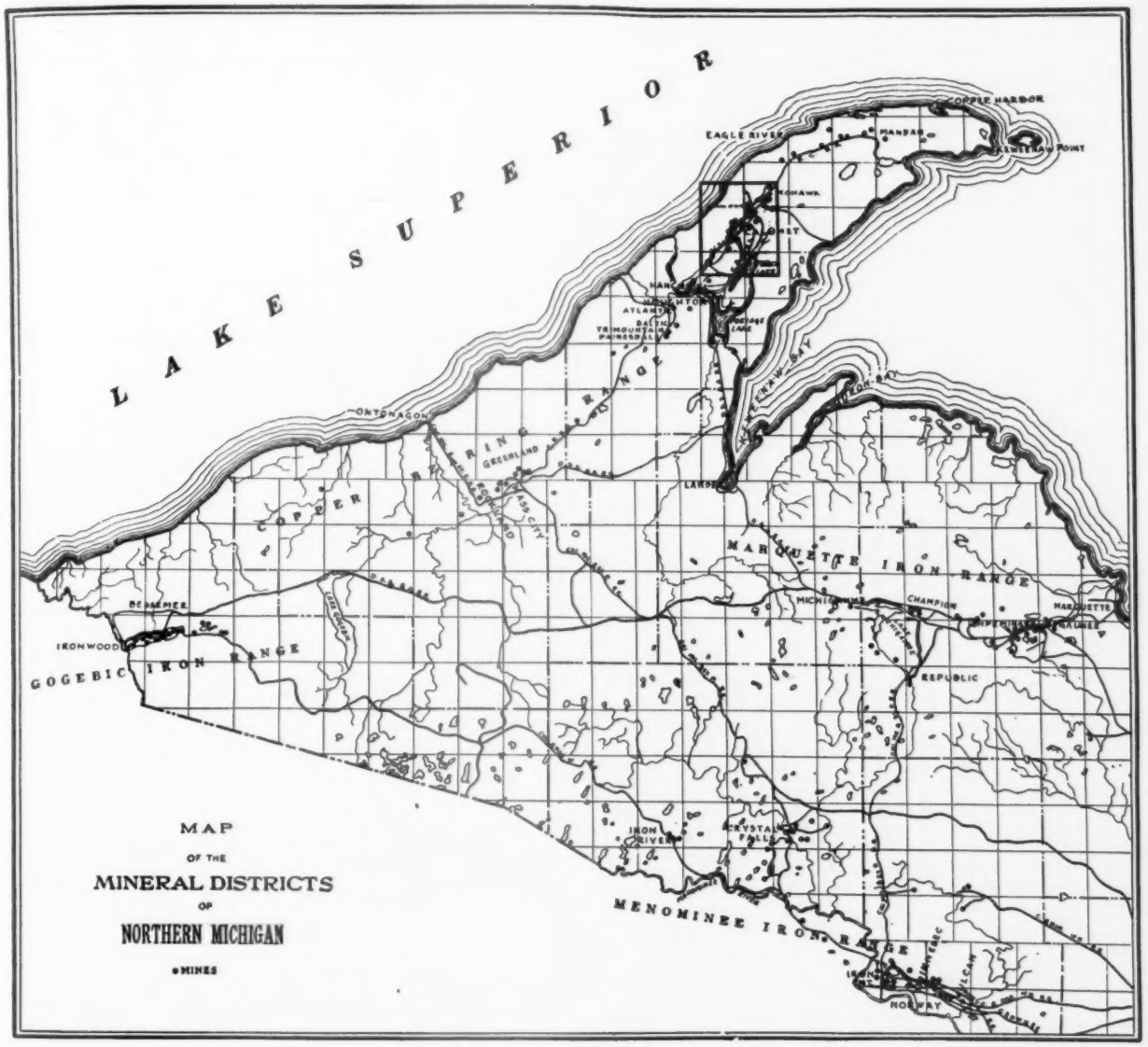
Improvements in the methods and facilities for handling the product of the mine had not kept pace with the greater depth and gradually increasing production. The maximum skip load was 5 tons. Crushing the ore in the mine shaft rockhouses was being done in two stages: a preliminary crushing of the coarser ore and a final crushing to reduce it to stamp mill size. The railroad from the mine to the mills at Lake Linden, over which the ore product was transported, was narrow gauge, while the railroad cars in use had a capacity of only 6½ tons each. While Wilfley tables had been developed and were being used successfully in connection with one stamp unit by the Calumet and Hecla, and while their use showed a material saving in copper over the current practice, they had not been generally adopted because of lack of room in the then existing stamp mills. Electric power for general use was just being introduced by the installation at Lake Linden of two units, each of 1,000 kw. capacity. At the smelter, located at Hubbell about three-quarters of a mile from the stamp mills, where the concentrates from the mills are melted and refined, there were small hand-fired furnaces with an average capacity of about 30,000 pounds, from which the resulting product was dipped and poured by hand.

At about that time the porphyry mines of the West were being developed and would soon be producing, new and important bodies of copper ore were being discovered in the Southwest, and because of the indicated large output and low operating costs of these new mines, it was evident they would prove formidable competitors and that to meet such competition a policy of rigid economy would have to be adopted. Such economies as could be accomplished without changing or adding to the existing equipment were first undertaken and when accomplished the equipment was altered or new equipment installed wherever a saving in operating cost would justify the change. The 5-ton skips were superseded by skips holding 7½ tons. Larger ore breakers were installed in the shaft rockhouses that would take the largest product from the mine and in one operation reduce it to stamp mill size. The gauge of the railroad was increased to standard and new cars of 40-ton capacity replaced the smaller ones. The concentrator section of the mills was torn down and new and larger additions built that permitted a material change in concentrating practice through the adoption of Chilean mills for regrinding the richer middlings from the jigs and Wilfley tables for treating this reground product and the original fines from the stamps. Inasmuch as the stamp mills had to be kept operating, these changes could only be made piecemeal and in consequence took four years to accomplish, but the saving in copper by the new practice was sufficient to pay for the entire change in a comparatively short time. Three units, each of 2,000 kw. capacity, were added to the electric power plant at Lake Linden; power lines were extended to the mine, and the underground steam and compressed air-driven pumps were superseded by electrically driven pumps. Steam engines for operating the ore breakers in the shaft rockhouses were replaced by electric motors, as were also the steam engines in the various shops and other surface plants. At the smelter three new reverberatory furnaces, each of 75,000-pound capacity, were built, two of which were equipped with Walker casting wheels, the third with a straight line casting machine for mechanical pouring.

THESE changes in equipment and enlargement of plants fully justified themselves by the ensuing reduction in operating costs. The Osceola lode mine was reopened, and by a more careful selection of the ore mined developed into a profitable venture, although not comparable with the conglomerate.

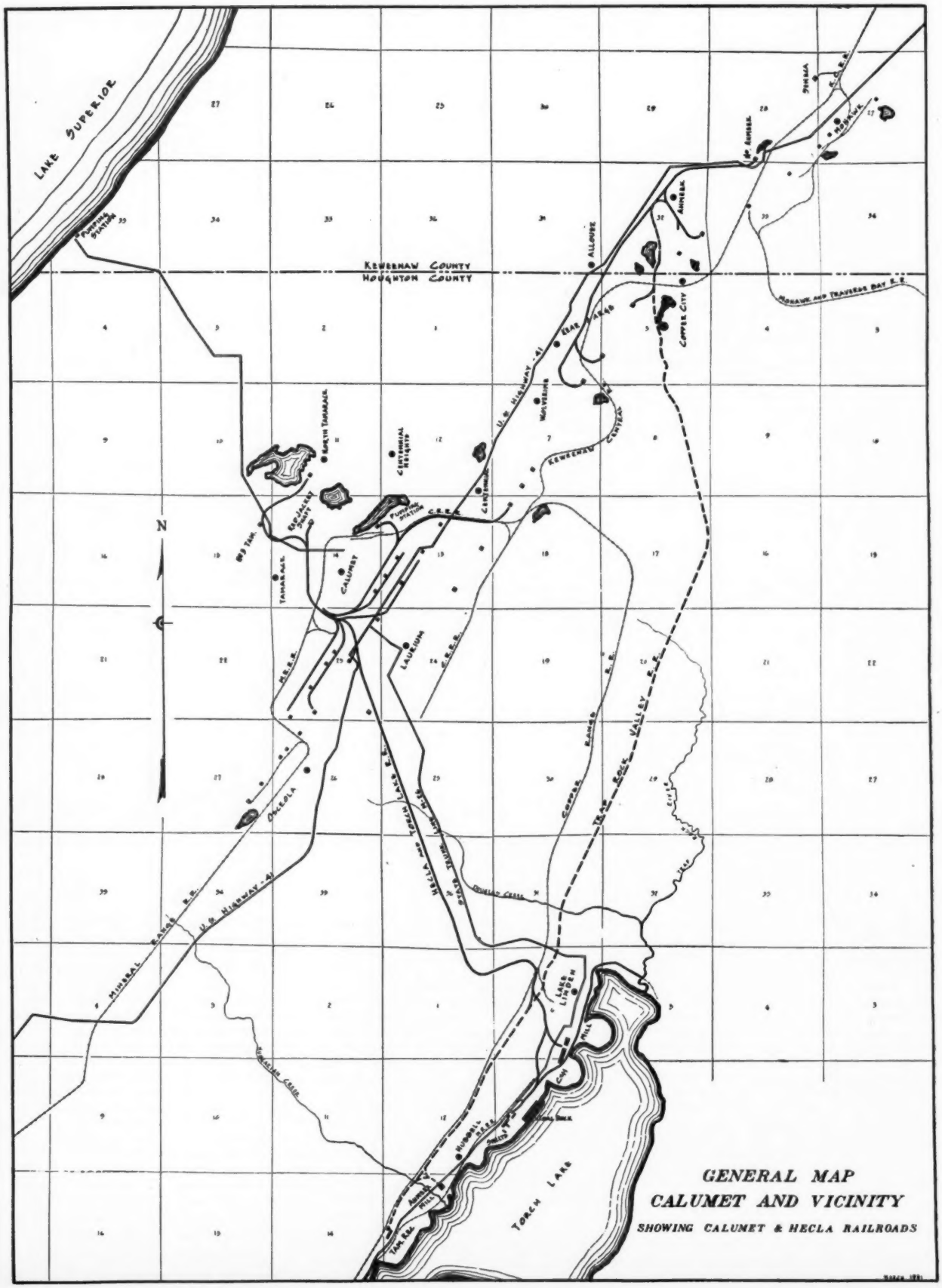
At the same time an expansion of the company's scale of operations seemed desirable; it therefore added to its holdings by the purchase of large tracts of mineral lands in Keweenaw County to the northeast of Calumet in the hope of finding new ore bodies, but although explorations by trenching, pitting, and diamond drilling were carried on for the following two or three years nothing of value was found. The Kearsarge lode

* President, Calumet and Hecla Consolidated Copper Company.



where it crosses the original Calumet and Hecla property was explored by shafts and drifts to depths of from 1,000 to 2,000 ft. and over a length of 2 miles, and, while some copper was found, the mineralization was not sufficiently concentrated for profitable operation. A controlling interest in the Superior mine was acquired by the purchase of treasury stock of the Superior Copper Company. This mine, located southwest of the Isle Royale mine in the horizon of the Baltic lode, was then in the development stage. The copper chute proved to be limited in size, and although the mine continued to operate until November, 1920, it was not a profitable venture. Later the physical assets, except cash, were bought by the Calumet and Hecla and the company dissolved. The company also organized and acquired majority interests in the LaSalle Copper Company and the White Pine Copper Company by supplying the working capital while landowners supplied the mineral lands. The LaSalle operated on the Kearsarge lode just south of Calumet; the White Pine on the Nonesuch shales in Ontonagon County, about 70 miles distant from Calumet. Both of these properties, though of low grade, were operated successfully during the time of the war when high prices for copper obtained but were closed down when all the company's mines suspended operations in 1921. Subsequently the White Pine mine was sold, but the Consolidated Company still owns a majority interest in the LaSalle Copper Company, although the mine is not in operation. From 1907 to 1909 stock interests were bought in the Ahmeek, Allouez, Centennial, Tamarack, Osceola Consolidated, and Isle Royale Companies, and the management of the mines of those companies was taken over by the Calumet and Hecla. For a time the identity of the several companies was maintained, and the mines were operated as separate units; but it soon became apparent, because of the contiguity of all but one of these mines, that greater economies could be secured by a consolidation into one company, by abandoning intervening boundary lines, making common use of the more favorably located plants, operating fewer shafts, centralizing management, accounting, purchasing, milling, smelting, and many other minor operations. Deeming such a consolidation highly desirable, a plan was proposed in 1911, but met with opposition on the part of some of the stockholders of the Ahmeek and Osceola Consolidated Companies, resulting in protracted litigation; consequently the plan was abandoned, and it was not until 1923 that a consolidation of all the companies mentioned, except Isle Royale, was effected.

From the beginning of mining by the Calumet and Hecla, practically all of the



CALUMET AND HECLA CONSOLIDATED COPPER COMPANY

mill tailings were deposited in Torch Lake, and as the conglomerate tailings contained an average of a little over 14 pounds of copper per ton, attempts had been made from time to time to re-treat them, but none of the experiments had proven commercially profitable. With the advent of the Chilean mill and a little later the pebble and ball mills for fine grinding, and the Wilfley tables for concentration, it became evident that these tailings could be re-treated profitably, and suitable plants for their recovery and treatment were built and went into operation in 1915. By this process of treatment, re-grinding and gravity concentration only about 35 to 40 per cent of the copper in each ton of tailings was saved. Efforts to save as much as possible of the remaining copper resulted in the development of a native copper leaching process, a plant for which was built and went into operation in 1916. These two processes resulted in a combined recovery of about 80 per cent of the copper in the original tailings as taken from the lake. Subsequently a third process, flotation, but applicable only to the slimes hitherto not treated, was added, the plant for which went into operation in 1918. By the adoption of these various processes, grinding, Wilfley table treatment, leaching and flotation, that large tonnage of sands, theretofore believed worthless, has returned many millions of dollars in profits.

THE copper district of Michigan had always been known as an "open shop" camp; indeed, the mines had always been free of labor union organizations. A few incipient strikes on the part of foreign workmen, usually the result of misunderstandings, had occurred from time to time at individual mines, but as the employes, in general, were industrious, contented and peaceful, these strikes were never protracted or of any serious moment, and at no time was there a general strike affecting all the mines of the district. As the number of employes increased and as the district assumed greater importance as a labor center, it was, no doubt, looked upon by mine union labor leaders as a fertile field in which to extend their activities, and for some years prior to 1913 emissaries of the Western Federation of Miners, a labor organization with headquarters at Denver, Colo., had been doing missionary work, especially among the newer members of the foreign element, with the result a general strike was called in July, 1913, affecting all the mines in the district and for a time all of them were closed. As was usually the case with the union in question, the strike was attended with great violence, necessitating the services of the entire National Guard of the state to restore and preserve order. As soon as the strike was called the principal officers of the union, all of whom were foreign to this part of the country, came to take charge, and while many grievances were enunciated and many demands were made by these officers, the principal demand was recognition of the Western Federation of Miners, to which the mining companies refused to accede. Within three weeks from the time the strike started, the Calumet and Hecla management was petitioned by 72 percent of its former employes, none of whom were members of the union, to reopen its mines and resume work, which was promptly done. The strike was not officially called off, however, until April, 1914, when most of the strikers, except those who had committed violence, were rehired and many of them are still in the employ of the company.

For a time after the outbreak of the World War there was no sale for copper abroad and only a limited demand in this country, necessitating a reduction in output. Accordingly, the mines were operated on a two-thirds time basis until the spring of 1915, when the demand for copper for war purposes became so great as to necessitate full-time operation at maximum production, this condition continuing until the signing of the Armistice.

IN 1916 the Calumet and Hecla Mining Company's mines had been in continuous operation for 50 years, with the exception of two or three minor interruptions by mine fires and the three-weeks' interruption due to the strike. To celebrate this event a general holiday was had, a parade of the more than 5,000 employes was reviewed by the directors and general officers of the company, addresses were made by the governor of the state, the president of the company, and by a former director, after which medals were awarded for long service. In this connection it is of interest to note that of the men then in the employ of the company, 824 received bronze medals for service between 20 and 30 years, 386 received silver medals for service between 30 and 40 years, and 169 received gold medals for service over 40 years. Of the latter number, one man had been in the employ of the company since the mine started.

As a result of the war's ending, there was a sudden let-up in demand for copper. Large quantities were held by the various governments involved in the war, while the fabricators throughout this country were left with supplies of copper much beyond their immediate needs. The transition from a war to a peace-time basis took considerable time in accomplishment and the years 1919-20-21 and 22 were lean ones for the copper industry. With so large an available supply throughout the world, the price receded faster than the production costs at the mines, and as copper stocks rapidly increased in the hands of the producers, there seemed no alternative but to stop production. Accordingly many of the mines throughout the country, including those under Calumet and Hecla management, were closed in April, 1921, and remained closed for a period of one year.

The advantages that would accrue to the companies owning contiguous properties, that prompted the consolidation proposal in 1911, still existed and with time had become more important as factors in their successful operation. Consequently in the early part of 1923 a new plan was proposed and successfully carried out, and in September of that year the Calumet and Hecla Consolidated Copper Company was organized. This company embraced the Calumet and Hecla Mining Company, Ahmeek Mining Company, Allouez Mining Company, Centennial Copper Mining Company, and Osceola Consolidated Mining Company. The Tamarack Mining Company had ceased to exist in 1917 when all of its physical assets were purchased by the Calumet and Hecla. The Isle Royale Copper Company was not included in the consolidation as its mines were not contiguous to the rest of the group, being about 15 miles distant.

In 1926 the company took options on large tracts of land in Keweenaw County adjoining lands it already owned. The property optioned from the Keweenaw Copper Company included the Phoenix mine, a fissure vein property that had not been operated for many years and consequently was filled with water. In 1928 this mine and the Cliff mine, an interest in which had been acquired by the Calumet and Hecla at the time of its purchase of Tamarack stock, were unwatered, and explorations have been in progress in the former until the present time and in the latter until February 1 of this year. Additional explorations are still being conducted on some of the optioned lands, as well as on some of the lands bought by the Calumet and Hecla in previous years.

A statement showing tons of ore treated, pounds of refined copper produced, pounds of copper recovered per ton of ore treated, and dividends of the Calumet and Hecla Mining Company and its successor, the Calumet and Hecla Consolidated Copper Company, from the beginning of operations through 1930, follows:

	Tons of ore treated	Lbs. of refined copper produced	Av. lbs. of copper per ton of ore treated	Dividends paid
From beginning through 1900	21,734,482	1,501,807,412	69.1	$72,850,000
1901-1930, both inclusive	66,415,547	2,035,457,909	30.6	$112,179,779*
Reclamation (sands)	24,768,000	268,641,000	10.85	
Totals	112,918,029	3,805,906,321	33.7	$185,029,779

* Of this amount $12,153,974 represents dividends received by the Calumet and Hecla Mining Company from its subsidiary companies that later entered the consolidation; and $1,111,320 represents dividends received from the Isle Royale and Superior Copper Companies.

CALUMET AND HECLA CONSOLIDATED COPPER COMPANY

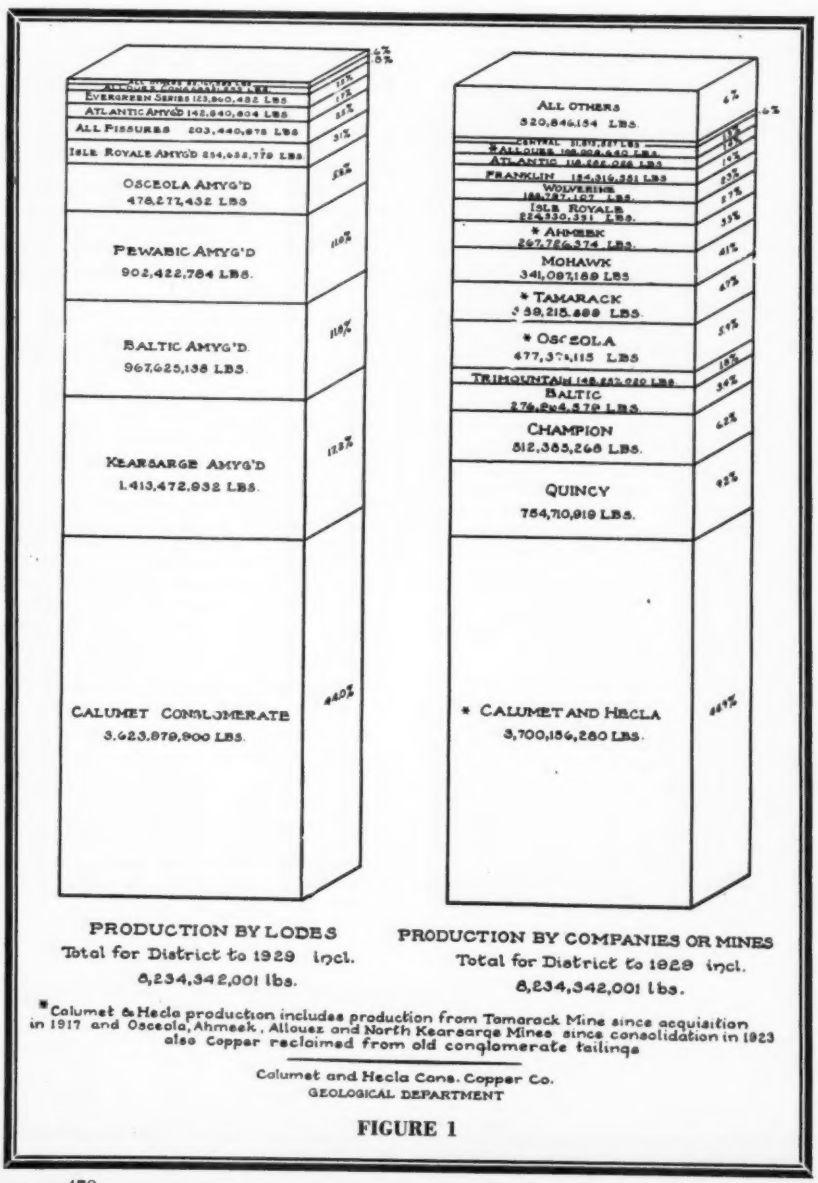
GEOLOGY and EXPLORATION in the Michigan Copper District*

By T. M. Broderick† and C. D. Hohl‡

THE Michigan copper district is the second largest producer of copper in the world, having produced 8,234,342,000 pounds of copper and having paid $325,-017,047 in dividends from the beginning of mining operations in 1845 to the end of 1929. (See *Figure 1.*) Of this total about 44 percent of the copper is to be credited to one ore body, the Calumet Conglomerate, while 48.9 percent was obtained from five amygdaloid ore bodies, the Kearsarge, Baltic, Pewabic, Osceola and Isle Royale. The fissure deposits, so important in the early history of the district and so interesting geologically, have played minor roles, having contributed less than 2½ percent of either the total copper produced or dividends paid. The district produced a total of 186,393,836 pounds of refined copper in 1929, which was distributed among the various lodes and companies as shown in *Table 1.*

General Geologic Features

In Keweenawan time some hundreds of basaltic flows were extravasated forming a series thousands of feet in thickness. Interbedded with the flows are felsite conglomerates, subordinate to the flows in number and thickness in the middle of the series, but abundant and thick in both the lower and upper parts of the Keweenawan. Interbedded with the traps rather rarely are felsite and quartz porphyry flows, and the whole series is intruded by gabbro and associated acidic differentiates, the intrusives ranging in size from small masses, such as Mount Bohemia in Michigan, to the great Duluth gabbro of Minnesota. These intrusives are especially abundant toward the base of the series on both limbs of the Lake Superior syncline; the largest one, the Duluth gabbro in Minnesota, lies along the plane of unconformity at the base of the Keweenawan, is about 10 miles in thickness and forms a tabular body dipping with the overlying lavas toward the center of the syncline. Thus the series has a large intrusive mass at its base of which the smaller intrusives in the Michigan copper district are probably offshoots. The flows and sediments are all thought to be land deposits, derived from a source down the present dip toward the center of Lake Superior.



*Calumet & Hecla production includes production from Tamarack Mine since acquisition in 1917 and Osceola, Ahmeek, Allouez and North Kearsarge Mines since consolidation in 1923 also Copper reclaimed from old conglomerate tailings

Calumet and Hecla Cons. Copper Co.
GEOLOGICAL DEPARTMENT

FIGURE 1

* For more detailed accounts see Butler, B. S., and Burbank, W. S., The Copper Deposits of Michigan, U. S. Geol. Surv., Prof. Paper 144, 1929. Broderick, T. M., Zoning in Michigan Copper Deposits and its Significance, Ec. Geol. Vol. XXIV. Nos. 2 and 3, 1929. Broderick, T. M., Fissure Vein and Lode Relations in Michigan Copper Deposits, in preparation.

† Chief Geologist, and ‡ Assistant Geologist, Calumet and Hecla Consolidated Copper Company.

TABLE I

REFINED COPPER PRODUCED IN 1929

Company	Calumet congl.	Kearsarge amygd.	Baltic amygd.	Osceola amygd.	Isle Royale amygd.	Pewabic amygd.	Ahmeek fissure	Totals
Calumet and Hecla Consolidated:								
Mine	35,377,000	35,744,025	.....	18,237,000	.....	.....	960,975	.....
Tailings reclamations	33,511,000	.....	.....	.....	.....	.....	.....	123,830,000
Copper range:								
Champion	.....	.....	20,660,701	.....	.....	.....	.....	.....
Baltic	.....	.....	2,127,926	.....	.....	.....	.....	.....
Trimountain	.....	.....	1,408,689	.....	.....	.....	.....	24,197,316
Mohawk	.....	20,043,127	.....	.....	.....	.....	.....	20,043,127
Isle Royale	.....	.....	.....	.....	10,864,085	.....	.....	10,864,085
Quincy	.....	.....	.....	.....	.....	4,459,426	.....	4,459,426
Seneca	.....	2,999,882	.....	.....	.....	.....	.....	2,999,882
Totals	68,888,000	58,787,034	24,197,316	18,237,000	10,864,085	4,459,426	960,975	186,393,836

The intrusives are thought to have been derived from the same magmatic chamber as the flows.

Each lava flow, as it cooled, gave off great quantities of gas, which collected into bubbles and rose to the top of the flow where most of it escaped. But as the flow became cooler, it also became more viscous and finally the gas bubbles were entrapped near the top, forming a cellular capping. In some cases the entrapped bubbles flattened out horizontally and coalesced with other flattened vesicles. In many of the flows the vesicular crust was broken up into fragments by subsequent movement or by further explosive outbursts of gas from the still liquid interior of the flow. These fragments of shattered vesicular rock tended to pile up in irregular heaps on the tops of the flows. Later filling of the vesicles produced the amygdaloids, which are classified as cellular, coalescing or fragmental, according to their physical condition as described. These amygdaloidal tops are distinctly red in color, and examinations of polished sections, supported by chemical analyses, show that there is a steady increase in hematite toward the tops of the flows. This hematite was formed by an oxidation of the original iron-bearing minerals of the traps; it evidently took place at high temperatures, probably while the flows were solidifying, and was accomplished largely by the escaping gases, although atmospheric oxygen may have played a part.

Most of the flows followed each other so closely that there is no evidence of any erosion or normal weathering between them. In some cases, however, there was an interval long enough to allow the surface to become broken up and to permit the finer sand thus produced to sift in between the larger fragments, forming what is known as the scoriaceous amygdaloid. If the interval was long enough and other conditions favorable, felsitic debris was carried in and deposited on the weathered surface, forming a felsite conglomerate. Thus we have scoriaceous amygdaloids commonly underlying conglomerates; although not all scoriaceous amygdaloids are overlain by conglomerates.

The structure of the district is rather simple. The large ore bodies so far found have all been on the Keweenaw Peninsula, which is on the south limb of the Lake Superior syncline. The beds dip to the northwest at increasingly flatter angles toward the axis of the syncline. They are cut off on the southeast by the Keweenaw fault, which is a thrust fault dipping nearly parallel with the beds and bringing the Keweenawan lavas and conglomerates on the northwest side against Cambrian sandstone on the southeast side. There are numerous branches of this fault in the lower part of the series; and, where the beds have transverse folds, there are associated transverse fissures. While there was probably considerable movement on the Keweenaw fault in late Keweenawan and Cambrian times, the main structural features (such as the big syncline, the minor transverse folds and numerous faults and fissures including the Keweenaw fault) were well developed when copper deposition occurred. (See *Figure 2.*)

Ore Deposits

As already stated, over 90 percent of the copper production of the district has come from six ore bodies—one in the Calumet Conglomerate and the other five in amygdaloids, viz: the Baltic, Isle Royale, Kearsarge, Osceola and Pewabic. All of these deposits lie within the central portion of the series, which consists chiefly of lava flows. The ore mineral is native copper. Although native silver occurs in minor amounts, it is not usually separated from the copper in treatment. Both copper sulphide and arsenide also occur, but not in commercial amounts.

The Calumet Conglomerate ore body occurs in a felsite conglomerate; although known for many miles as a sedimentary horizon, it exists over most of its known extent as a thin sandstone or shale, in many places but a few inches in thickness. At Calumet, however, it opens out into a body from 5 to more than 20 ft. in thickness and becomes much coarser, with many pebbles and boulders up to 6 or 8 in. in diameter and some much larger. This conglomerate lens lengthens and thickens down the dip and the copper is confined to this body, the depositing solutions apparently having been unable to penetrate the sandy or shaly margins that close in on the conglomerate lens like the sides of an inverted funnel. The copper with adularia, epidote, calcite and quartz was deposited chiefly as replacement of the finer material between the pebbles. The richest mineralization occurred rather near the surface where the solutions flowed through the more constricted portions of the lens. Zeolites or zeolitic minerals, such as datolite and prehnite, are not found in the Calumet Conglomerate. The rock immediately associated with the copper is bleached as a result of the removal of the primary hematite of the felsite pebbles and of the detrital hematite grains in the finer cementing material by the ore-depositing solutions.

The amygdaloid lodes are of a permeable type because of their fragmental character; although those of the Pewabic series are permeable in part because of the coalescing of the amygdules. None of the numerous cellular amygdaloids have been found to be copper-bearing commercially. Minerals found in the various amygdaloid lodes comprise a greater variety than do those in the conglomerate lode, among them being quartz, epidote, chlorite, calcite, pumpellyite, adularia, sericite, ankerite, datolite, prehnite and some zeolites. In most of these deposits there is a rock alteration immediately associated with the copper, which has resulted either in the total removal of the iron originally in the primary hematite of the lode or in its reduction to the ferrous state and incorporation in ferrous silicates.

Some of the deposits are characterized by a gangue of sericite and ankerite with sulfides and arsenides in small amounts. Others have adularia-prehnite gangue as characteristic minerals with smaller arsenic and sulphur content. Still others have greater amounts of zeolites and are practically sulphur- and arsenic-free. These types of mineralization are regarded as having been formed at lower temperatures in the order named, and, therefore, represent different temperature zones. The three zones grade into each other and commercial copper occurs in all of them. Calculations based upon the rate of increase in the ratio of arsenic to copper in depth indicate that commercial copper was deposited over a distance of more than 20,000 ft. down the dip of the lodes. This estimate seems not unreasonable, since mines like the Calumet & Hecla and Quincy already have followed copper about 10,000 ft. down the dip and are still in commercial mineralization.

Apparently among the conditions that an amygdaloid or conglomerate should have had in order to make an ore body were the following: (1) it should have had access to the sources of the copper-bearing solutions in depth, either directly or indirectly, perhaps being fed by fissures that in turn made connections with the sources; (2) it should have offered a through-going solution channel, that is, it should have been a continuously permeable body as compared with

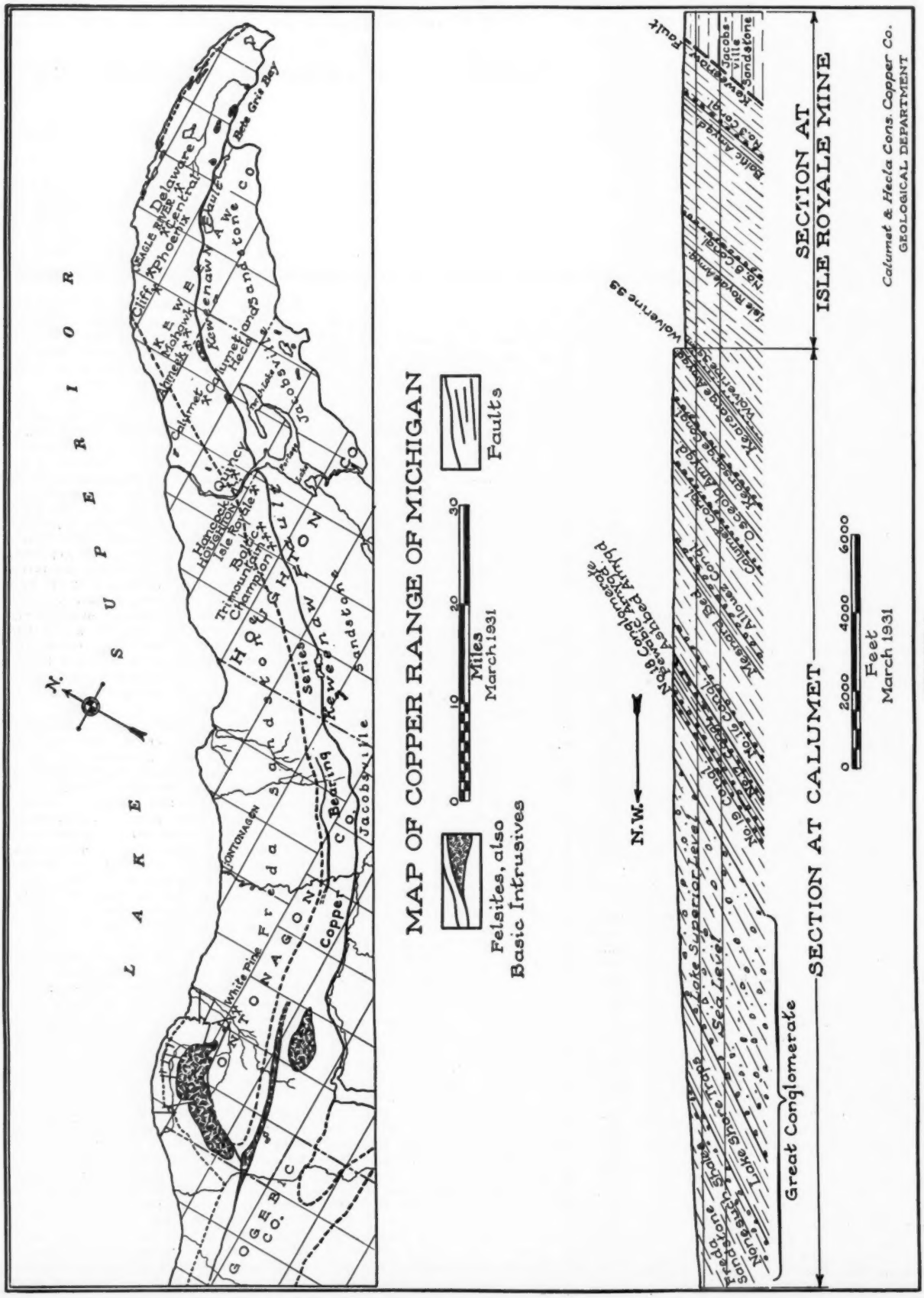

MAP OF COPPER RANGE OF MICHIGAN
Faults
Felsites, also Basic Intrusives
Miles March 1931
SECTION AT ISLE ROYALE MINE
SECTION AT CALUMET
Great Conglomerate
Feet March 1931
Calumet & Hecla Cons. Copper Co. GEOLOGICAL DEPARTMENT
N.W.
Fault
Lake Superior
Keweenaw Bay
Portage Lake
Lake Superior Sandstone
Jacobsville Sandstone
Copper Bearing Series
Keweenawan Series
Huronian Series
Archean
Portage Entry
Portage Lake Lava Series
Lake Shore Trap
Sand Hill Trap
Pewabic Amygdaloid
Quincy Amygdaloid
Osceola Amygdaloid
Calumet Conglomerate
Kearsarge Amygdaloid
Wolverine Amygdaloid
Isle Royale Amygdaloid
No. 3 Conglomerate
No. 2 Conglomerate
No. 1 Conglomerate
Kearsarge Conglomerate
Wolverine 33
Wolverine 39
Quincy
Hancock
Isle Royale
Trimountain
Champion
Boltdick
Calumet & Hecla
Mohawk
Ahmeek
Delaware
Phoenix
Central
Eagle River
Cliff
Keweenaw Copper Co.
Houghton County
Gogebic Co.
Ontonagon County
White Pine
Bohemian Range

FIGURE 2

the adjacent rock; and (3) there should have been suitable restrictions to the permeable portion. All of the ore bodies are in relatively permeable rocks; but, apparently, some sort of a barrier was necessary to prevent the solutions from spreading out and dissipating their copper values in great bodies of non-commercial grade. Solutions ascending the Calumet Conglomerate, for instance, were confined by the gradually converging shale margins. Those ascending the Osceola amygdaloid were deflected under long, raking bars of tight, cellular amygdaloid.

All of the known ore shoots come to the rock surface somewhere with good copper values. There is no evidence of a leaching of copper at the surface with a redeposition at depth. As will be explained, however, there is reason to believe that there may be undiscovered deposits in the district that do not reach the present surface and the attempt to locate them is the object of exploratory work now in progress.

Genesis of Deposits

There are two strongly contrasting theories to account for the native copper deposits. One is that cold, oxidizing, chloride waters descended from the surface for many thousands of feet by gravity or by atmospheric pressure, first percolating through hot traps and gathering up disseminated copper, then carrying it laterally and downward into amygdaloids and conglomerates, where the solutions reacted with the ferrous silicates, forming native copper and ferric compounds. According to this theory, the traps are essential as sources of copper and the chloride waters as carriers, and the deposits should be found on the upper sides of impermeable barriers.

The theory favored by the Calumet and Hecla geologists is that underlying intrusives, known to exist in the Lake Superior Keweenawan, on crystallizing, gave off solutions rich in copper, arsenic and sulphur; expelled under enormous pressures, they followed permeable amygdaloid and conglomerate channels upward, cooling and entering regions of lower pressure as they ascended; reacting with the highly oxidizing wall rock, they had their arsenic and sulphur oxidized by the ferric iron of the lodes and their copper deposited as native metal. According to this theory, the traps are not essential to the formation of the ore bodies. The copper did not come from them, and any other oxidizing environment would have served to precipitate native copper, just as actually is the case in Coro Coro, Bolivia, where native copper was deposited in commercial quantities in red sandstones, there being no lava flows in the district. The chloride waters now found in the mines are not regarded as being necessary to explain the native copper. The copper deposits should be found underlying impermeable barriers.

Exploration

Most of the known amygdaloid and fissure deposits were found with copper showing in the outcrops. In some cases a prehistoric race had mined the rock at the surface and the white men later "rediscovered" the deposits by cleaning out the old pits. These prehistoric miners sometimes dug pits at convenient places to cache their copper; and by a strange coincidence, as the story goes, after one of these random caches containing amygdaloid copper had been cleaned out and deepened a few feet, it was found to be directly over a part of the rich Calumet conglomerate ore body. There is some reason to believe that this pit was not simply a cache for the amygdaloid copper found in it, but that it actually encountered such mineralization in bed rock, since early accounts mention the fact that an amygdaloid in the immediate hanging-wall of the conglomerate was found to be mineralized at this point. Thus by examination of the small percentage of the bed rock that is not thickly covered with glacial sand and gravel and by opening up the ancient miners' pits, the major ore bodies of the district have been found. The last commercial ore body to be discovered was the one on the Baltic lode. Since that time, about 50 years ago, many millions of dollars have been spent in diamond drilling, trenching and underground work without discovering a new ore body. In the face of this long period of expensive exploration with negative results, what encouragement is there for further search for new ore bodies? Some of the considerations involved in exploration will be briefly reviewed.

Only a small percentage of the copper-bearing formation is not drift covered. Yet the examination of this small percentage outcropping led to the discovery of most of the amygdaloid and fissure ore bodies. While the drift covering hampers exploration, the very fact that it is so universally present leads to the conviction that there must be undiscovered ore bodies. If the rock everywhere outcropped, there would be little chance of finding new deposits exposed at the surface after 85 years of search.

Copper deposits are known to occur over an area of some hundreds of square miles. This is to be contrasted with other districts, such as Butte, where a similar production has come from but a few square miles. Thus in this district the explorer is handicapped by the enormous areas of barren ground in the midst of which commercial deposits must be sought. On the other hand, it means just so many more square miles in which deposits may occur.

There seems to be a generally accepted notion that enormous tonnages of rock exist with a copper content just below that required for a profit. The Ashbed and the Allouz conglomerates are often mentioned as horizons that contain appreciable mineralization over large areas, because they are known to have some copper at widely spaced localities. While the idea that higher prices for copper would increase the reserves of commercial ore is true to some extent, such an increase would by no means be as great as is generally believed. Past experience in this district indicates that the rich deposits are large and the leaner deposits are smaller.

While mineralogical studies have been a feature of all of the geological surveys of the district, nothing very positive of a mineralogical nature has been developed to serve as a guide in exploration. It is recognized, however, that the commercial lodes have a greater variety of minerals than has the average amygdaloid. The recognition of the approximate position of a prospect in the zonal range by means of the arsenic ratio and characteristic gangue minerals is, of course, an advantage.

A study of surface geology is an inexpensive and necessary first step in exploration. It resulted in the discovery of most of the deposits in the district and has furnished a fund of information on the general geology. The chances that any new deposits can be found by inspection of surface outcrops now are exceedingly remote. Where the overburden is thin enough, trench and test pitting may be used to advantage.

Diamond drilling is the most satisfactory method of determining the general geologic conditions, such as kinds of rocks and character and position of lodes, where any considerable depth of overburden exists. But it is not a reliable method of determining copper values, because of the very erratic distribution of the metal. The drill may encounter local bunches of copper in a worthless lode; and, on the other hand, in going through ordinary amygdaloid lodes of commercial grade, it is more than likely to miss the copper. Where values are quite uniformly distributed, as in a sandstone or conglomerate ore body, the drill has a better chance to secure a good sample of the copper content.

It was hoped that geophysical methods would be useful in the search for new deposits, but after a variety of electrical and magnetic methods had been tried out, the results were found to be disappointing. The copper is so small in amount and so disseminated that its effect on electrical methods is little or not greater than the effects caused by differences in thickness and character of overburden and differences in bed rock character. So far as magnetic methods are concerned, there are no known magnetic effects connected in any way with the ore bodies. Various geophysical methods, however, are somewhat useful in preliminary geological work, such as laying out diamond drill locations. For such work the dip needle has so far been found to be satisfactory, as it affords a rapid method of determining the main features of the geological structure. It could have been used to considerable advantage in earlier years in some places where the local strike was not so well known as it is at present.

Underground methods must eventually be employed in any exploration. After the diamond drill or any other method has done all that it can in determining the general geological features of an area, actual underground openings must be made to locate ore and to determine its grade. For every major lode deposit there are scores of erratic and local patches of mineralization scattered throughout the Keweenawan series, not only in Michigan but in the entire Lake Superior district. It is only by opening up the lodes for hundreds or thousands of feet that it can be determined whether or not the mineralization is of importance; and large scale mill runs are necessary to determine the grade, since ordinary sampling methods are useless, due to the erratic nature of the mineralization.

It is apparent that the ore bodies are determined by favorable conditions of a purely local (*Contniued on page* 486)

CALUMET AND HECLA CONSOLIDATED COPPER COMPANY

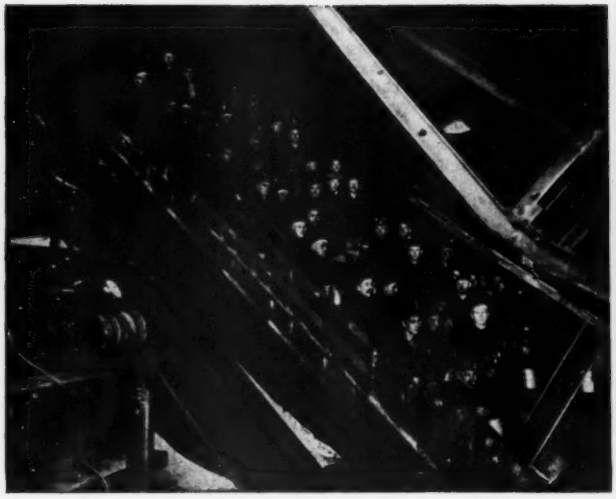


Figure 1-a. Man cage, No. 2 Ahmeek Shaft

Figure 1. Eight-ton skip on drop switch, No. 2 Ahmeek Shaft

Mining Methods in the Amygdaloid Lodes–

Kearsarge Lode Operations

By Ocha Potter*

ACTIVE production from the Kearsarge lode was started at the Kearsarge mine, later called North Kearsarge, in 1887, and has been carried on without much interruption ever since. The Lode has been opened, developed and profitably mined over a continuous length of nearly six miles. The Wolverine mine began operations in 1895 and its success was quickly followed by development work at neighboring properties—the South Kearsarge, Centennial, Mohawk, Ahmeek, and Allouez—with considerable success also. Excepting only the Calumet conglomerate, the Kearsarge lode has been the greatest contributor to mining profits in the district and is now the largest producer. All the mines mentioned, aside from Wolverine and Mohawk, are now owned by the Calumet and Hecla Consolidated Copper Company, and at the present time six shafts are in service—three at Ahmeek, two at North Kearsarge and one at Centennial.

Operating methods on the Kearsarge lode have been revised to meet changing conditions during the past 10 years, and little remains in 1931 with which the miner of 1920 was familiar. Methods of stoping, drifting, tramming, skip-loading, hoisting and pumping have all been speeded up or changed in the in-

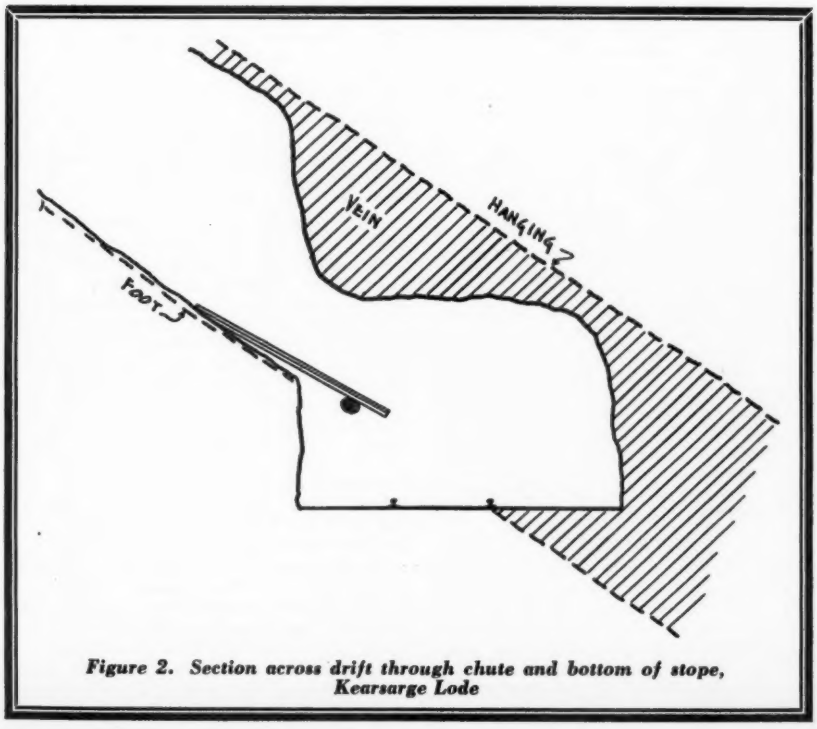


Figure 2. Section across drift through chute and bottom of stope, Kearsarge Lode

* Superintendent of the Ahmeek-Kearsarge Branch, Calumet and Hecla Consolidated Copper Company.

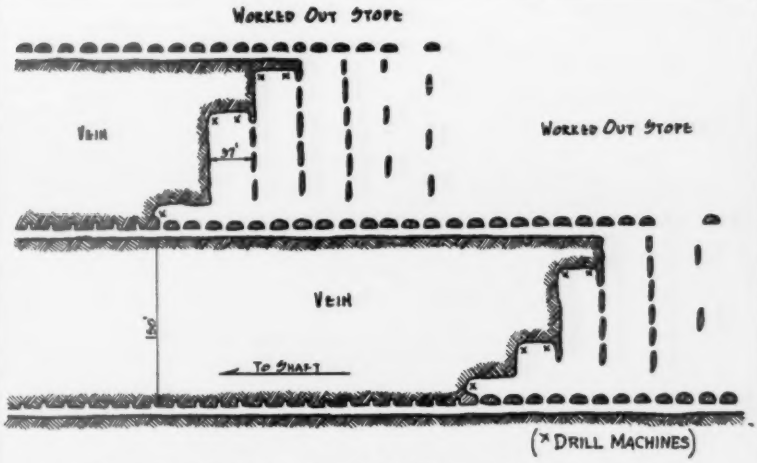


Figure 3. Ideal plan view of rib pillar stoping, Kearsarge Lode

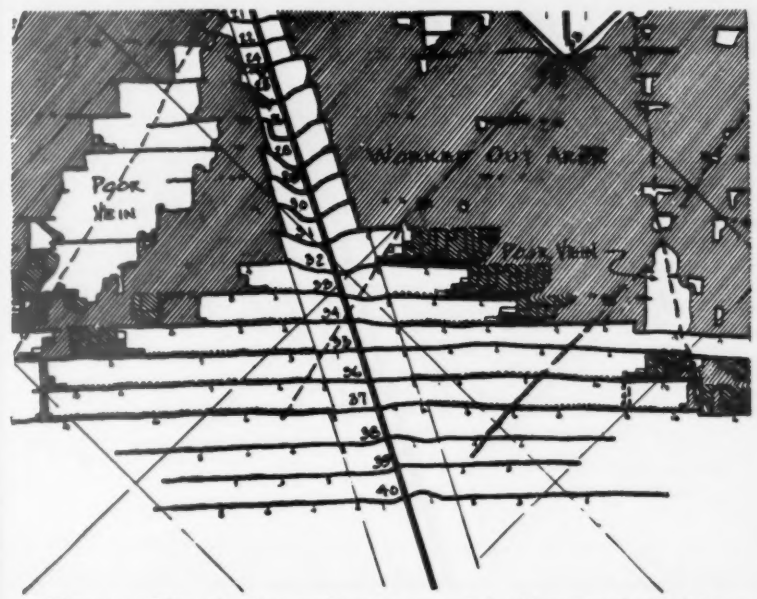


Figure 4. Plan of active workings in one of the Kearsarge Lode shafts

terest of operating efficiency and production maintenance.

SHAFTS

The original stoping practice in these mines did not leave more than 50 ft. as a pillar on each side of the shaft; but as depth increased, pressure from the hanging-wall also increased and shaft pillars were gradually lengthened until, at a depth of 5,000 ft. and over, they are 400 ft. long—200 ft. on each side of the shaft.

The distance between levels has been standardized at 150 ft. on the slope of the lode. When sinking, it is customary to leave a solid rock pentice under the skip roads and three "lifts," or 450 ft., are sunk and timbered before this pentice is removed. The standard sinking equipment consists of a half-ton bucket suspended from a carriage running on an I-beam and drawn up by an electric hoist. The shaft walls are given two coats of gunite to delay air-slaking and slabbing, and all plats are whitewashed to improve the lighting. For dividers between shaft compartments 10-in. by 10-in. Oregon fir is used and shaft sleepers are of the same material and spaced 5 ft. apart. Stringers of creasoted southern pine fastened to the sleepers with lag-screws carry 60-lb. steel rails, which are prevented from tilting by specially designed cast-steel brackets placed on the outside of each rail. All shafts in the active mining area are sunk in the vein and are inclined at an angle of approximately 36 degrees below the horizontal. In order to maintain production from the increased depths reached in recent years, faster skip-loading, faster hoisting and larger skip loads have become necessary. Two shafts are equipped with skips of 8-ton capacity, while the other shafts have 5-ton skips. The tram car loads are dumped through the back of the plat between the rails directly into the skips. Skip gates are not used; as the skip fills, it lowers a few feet while taking up the slack in the hoisting cable, but spilling is avoided by having the sides of the skip longer than the back. (See *Figure 1*, a skip in the Ahmeek mine.)

The skip wheels are manganese steel and are fitted with Timken roller bearings. Hoisting speed of ore is from 3,000 to 3,500 ft. per minute, all hoisting engines being equipped with Lilly controllers. When men are to be handled through the shaft, cages having a capacity for 40 are used and the running speed is limited to a maximum of 1,000 ft. per minute. (See *Figure 1-A*, cage load of men.)

DRIFTING

Drifts are carried approximately 9 ft. high by 14 ft. wide, and the ordinary side-cut is used. In the upper levels the plan of cutting in toward the hanging resulted in high efficiency because the vein breaks freely from the hanging; but at depth this method became impracticable since the unavoidable breakage of the hanging was invariably followed by caving trouble. Present practice is to cut in toward the foot, leaving some of the vein on the hanging-wall so that it will not be shattered by the

Figure 5. Stope in Ahmeek Mine, diagonal view along line of rib pillars

blasting. (See *Figure 2.*) This vein material also prevents air-slaking and consequently retards caving of the hanging.

Drift-miners are paid according to the number of feet they advance, as measured each month, and are charged for explosives as a part of their contract. A contract is let to two miners who share the net proceeds equitably according to the number of days worked by each. One miner works on each shift, barring the loose, setting up the machine, drilling, charging and blasting. He is seldom alone as the amount of ore broken on the opposite shift usually requires one or two trammers for its removal. An average of 35 holes is necessary to break a round for an advance of 5½ or 6 ft. "Atlas A"—a semi-bulky powder—is used for the main part of each charge but two or three sticks of 50 percent gelatin are put in the bottom of each hole.

Figure 6. Stope in Ahmeek Mine. Side view of a line of rib pillars. Pillars in foreground have been removed and stope cleaned

STOPING

Until a depth of about 3,000 ft. on the lode was reached, the open stope method was generally used. When poor vein was encountered it was left as a pillar to support the hanging, and in general there were enough poor or lean areas to answer the purpose. As the depth and pressure increased, however, a more uniform system of temporary support became necessary. The first step was the adoption of the "retreating" system of stoping, and the second step was the development of what has been named the "rib pillar" method of stoping. (See *Figure 3.*)

The development of a set of stopes on any one level may be described as follows: A drift 9 ft. by 14 ft. in section, which cuts into the footwall to a depth of 5 ft. below the vein, is advanced to the boundary. Starting at the end of the completed opening and spaced along the drift on 21-ft. centers, a series of raises are driven in the vein to a height of approximately 10 ft. These serve to open the stopes and are used later as chutes to remove the ore. From the top of the boundary raise a "cutting-over" drift is next driven toward the shaft, breaking, as it advances, into the tops of the successive raises, which are thus cut away to form funnel-shaped openings. (See *Figure 4*, plan of active workings.) When four chutes have been completed, the first raise-stope, 37 ft. long, is started over the two center chutes, leaving the end chutes open for ventilation. As this first stope progresses toward the level above, the process of cutting and "holing-over" additional chutes continues; then a second raise-stope, 37 ft. in length, is started, leaving between the new stope and the old a pillar 5 ft. thick that is known as the "rib pillar" because of its long and narrow shape. This pillar is divided into sections by holes about every 25 ft., which allow ready access between stopes and permit free movement of air currents. (*Figures 5* and *6* show typical

Figure 7. Eight-ton car in dumping position

Figure 8 Coming out to shaft with a train of 8-ton cars, Ahmeek Mine

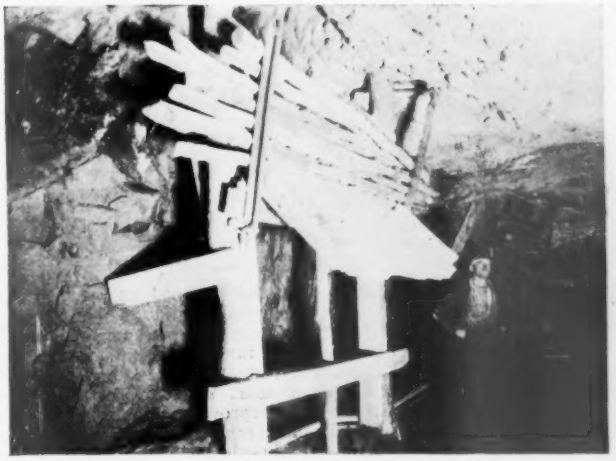


Figure 10. Standard stope chute, Ahmeek Mine

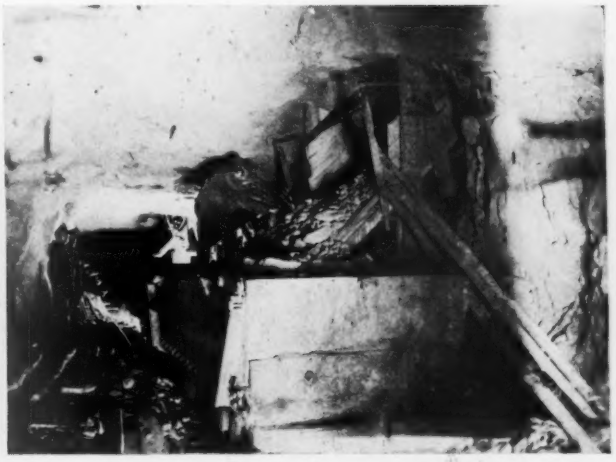


Figure 9. Loading 8-ton car from stope chute, Ahmeek Mine

open-stopes with "rib pillars.") Two machines work in each raise-stope and it has been found that four stoping machines keep pace with one machine cutting-over chutes. Two stopes and one cutting-over operation, requiring five machines in all, produce from 220 to 250 tons per day of two shifts, which is the normal production from each retreating stope group. (See *Figure 3.*)

The "rib pillars" give only temporary support and are expected to fail under the concentrated pressure of the hanging-wall shortly after a stope is completed; furthermore, their failure is expected to take place gradually and in a manner that offers a cushioning effect to the subsiding hanging and avoids sudden collapse. No timber is used to support the hanging except an occasional prop to hold up a loosened block which may not be pried down. The pillar thickness is determined largely by experience and varies somewhat according to the character of the vein and hanging. After the stopes have been cleared of broken ore, the better grade pillars are blasted out; where the hanging is strong, an entire row of them may be recovered. Actual total recovery is approximately 95 percent of the commercial ore.

Three particularly important features of the "rib pillar" stoping method are as follows: *First*, all holes are drilled upward along the dip and hence are easily directed so as to avoid breaking into the foot or hanging; thus caving and consequent ore dilution are greatly reduced. *Second*, when the hanging collapses in the old workings, as it does frequently, the caving is stopped at the first solid line of pillars and the men in the active workings are not in danger. *Third*, the expense incident to stope timbering is avoided. The fact that stope-miners are practically *drifting* upward and are frequently "cutting-in," with consequent low tonnage and high powder costs, offers a disadvantage, of course; but it is fully compensated by the advantages mentioned. An increase in ore grade, which became evident shortly after the complete introduction of the method, was favorably affected by adoption of the present plan of paying stope-miners, all of whom are on a bonus system with a minimum wage; the total footage of holes drilled on each individual shift determines the bonus earned. This system requires a minimum footage of 40 ft. in one shift, and a bonus of several cents per foot is paid for each foot of hole drilled over the minimum requirement. Each miner has his own contract and therefore reaps the full benefit of his own efforts. Every hole that is drilled during the shift is measured by the shift-bosses who must see that all stope holes are properly placed with respect to foot and hanging, copper-bearing and poor vein, and that they are relatively of the proper depth. Improperly drilled holes are not counted in figuring the bonus. Shift-bosses are paid a monthly salary and are held responsible for every operation within their territory, which is limited to an area they can cover thoroughly at least three times each shift.

Tramming

In shafts using 8-ton skips, 8-ton tram cars are standard; in other shafts 5-ton cars are the rule. The 8-ton cars are built with bottom liners over wooden cushions and with Linatex-rubber-cushioned bumpers; they are 12 ft. long; 5

PUMPING DATA ON THE KEARSARGE LODE

Location of Pumps	Kind of Pumps and Sizes	No. of Pumps & Capacity in Gallons per minute	Head Pumped Against	Total Gallons Pumped to Surface in the year 1930
North Kearsarge				
No. 1 Shaft	Hor. duplex 5½ in. x 24 in.	2—500	1,200 ft.	135,700,000
	Hor. duplex 5 3/16 in. x 24 in.	1—430	1,000 ft.	.....
No. 4 Shaft	Vert. triplex 5 in. x 6 in.	1—150	350 ft.	20,196,000
Ahmeek Mine				
No. 1 Shaft	Vert. triplex 6½ in. x 7 in.	1—175	150 ft.	5,828,000
No. 2 Shaft	Vert. triplex 6¼ in. x 10 in.	1—300	1,050 ft.	26,658,000
	Hor. duplex 4¾ in. x 18 in.	2—280	2,200 ft.	145,942,000
	Vert. triplex 5 in. x 10 in.	1—150	1,050 ft.	.....
	Hor. duplex 4¾ in. x 18 in.	3—280	2,200 ft.	.....
	Vert. triplex 3 in. x 5 in.	1—60	1,200 ft.	.....
No. 3 & 4 Shaft	Vert. triplex 3 in. x 5 in.	3—60	1,200 ft.	.....
No. 4 Shaft	Hor. duplex 4¾ in. x 18 in.	2—280	2,200 ft.	145,051,000
Allouez Mine	Vert. triplex 4 in. x 5 in.	1—50	200 ft.	1,750,000
Centennial	Vert. triplex 3 in. x 5 in.	1—60	1,200 ft.	
Total				481,125,000

(Or 915 gallons per minute over the entire year)

Figure 11. Pump station, 34th level, No. 2, Ahmeek Shaft

ft. wide and 2 ft. 6 in. deep (inside the box) and are set on eight-coiled springs. They are designed for end-dumping by means of air-lifts and are fitted with doors at both ends. All tram-car wheels are made of manganese steel, and Timken roller bearings are used on those most recently built. (See *Figure 7.*) Track gauge is 3 ft. 4 in. and rails are 35-lb. steel. Seven-ton chassis, storage-battery, Goodman locomotives haul from two to four 8-ton cars; and 3-ton locomotives of the same type are used for the 5-ton cars. (See *Figure 8.*) The maximum length of haul from stopes is about 5,000 ft., although the usual haul does not exceed 2,500 ft.

Cars are loaded from stopes through the chute-raises, previously described, the bottoms of which are on the foot of the vein, thereby giving the maximum possible pitch for loading. (See *Figure 9.*) Only a little timber is required for each chute, i. e., two small hardwood logs, a 6-in. flat crosspiece between them, a few 2-in. maple planks and some 2- or 3-in. maple poles for stoppers. To keep the stoppers in place, chute irons of standard size and shape are made from old drift rails and are recovered for further use when the stope is worked out. (See photo of chute, *Figure 10.*) Approximately 85 percent of the ore broken in the stopes is loaded into tram cars by gravity with some assistance on the part of the trammers. Occasionally where rolls in the foot occur, a manganese-tipped scraper 4 ft. in width is used. Motive power is supplied by double-drum air engines using half-inch wire ropes. Such scrapers are always required in removal of stope pillars and in areas having a loose or dangerous hanging.

On account of the limited size and the numerous abrupt curves, mechanical loading has not proved successful in drift headings and all ore from drifts is loaded by hand. Tramming from both stopes and drifts is done on contract at a straight price per car loaded and delivered into the skip. There is a minimum wage for trammers but no maximum limit in earnings. Each shift is a separate contract; hence each man has every inducement to earn as much as possible every day.

General

The Chicago Pneumatic No. 6, anvil-block type drilling machine is standard and is used entirely as a "one-man machine." Drill steel is hollow, straight carbon, 1-in. hexagon, without lugs or collars, its quality being determined by the "block test." Starting gauge is 1⅝ in. and there is a drop in gauge of ⅛-in. for each 22-in. run. An average of 12 to 14 drills are dulled per machine shift. Air pressure is held very closely to 80 lbs. delivered at the machine. Fans and 12-in. tubing supply fresh air to the drift headings on the lower levels and natural draft provides ample ventilation in the stopes.

The flow of water into the mines has increased materially in recent years, as shown by the following tabulation, which lists all the pumping equipment in use. (See *Figure 11.*)

GEOLOGY AND EXPLORATION IN MICHIGAN COPPER

(From page 481)

character, such as access to the source of solutions in depth, throughgoing permeability and suitable restrictions by barriers. Even though a given horizon fulfills all of the necessary conditions, and has an ore body at one place, it would be purely a coincidence if that same horizon should be found to have the necessary conditions in another place. Nevertheless, much of the exploratory work htiherto done in the district has been based upon the idea that a horizon having one ore body is likely to have others.

In recent years the method of exploration adopted by the Calumet and Hecla Consolidated Copper Company has been to crosscut those parts of the series that, by diamond drilling or other means, are known to have exceptionally numerous horizons of a favorable physical character. These crosscuts are driven from conveniently located places in the mines or from shallow shafts sunk for the purpose. This method has an advantage over the old one in that numerous favorable horizons are crosscut instead of the work being confined to one bed. It is not improbable that a bed known to have an ore deposit, perhaps many miles away, due to favorable conditions there, may, at the place being explored, possess a most unfavorable character. Even this improved method is unsatisfactory, however. It lacks definiteness in that specific places of outstanding attractiveness are not indicated; and, furthermore, some of the known ore bodies are in the only favorable horizon for hundreds of feet in either direction. Therefore the policy of exploring in belts of dominantly favorable amygdaloids would fail to find such ore bodies as occur in isolated favorable lodes.

Geological studies during the past few years indicate more specific places to explore. A study of the relationships of lode mineralization and fissure mineralization has developed the idea that some of the fissures were mineralized by solutions that leaked away from the major amygdaloid or conglomerate channels. Especially would this be the case if the lode were partially blocked off by the barriers closing in more or less completely, in which case the solutions might be able to make their way upward above such places only by escaping through the fissures intersecting the lode. In the few known examples where such a relationship between fissure and lode seems to exist, the copper does not continue on the fissure right down to the feeding lode. There is a gap of hundreds of feet of fissure vein in which there is not much copper. This situation leads to the speculation as to whether or not the old fissure veins that were so prominent in the early history of the district as producers of mass copper may not have been merely the vents for the solutions that escaped from some important amygdaloid or conglomerate ore body at greater depth. These fissure deposits were worked to comparatively shallow depths where they became too lean to mine; yet they continue downward as strong fissure veins filled with gangue minerals of a type that indicates they are still high up in the zonal range over which copper is deposited in this district. In order to test this idea, two of the old fissure-vein mines, the Cliff and the Phoenix, have been unwatered, and an attempt is being made to find a major amygdaloid or conglomerate deposit which acted as a feeder for the fissures. The chief elements of uncertainty, of course, are whether these particular fissures have such a relationship to a lode solution channelway, and if so, whether that lode has commercial mineralization, and whether the gap between the bottom of the commercial mineralization in the fissures and the lode mineralization is short enough so that a reasonable expenditure will succeed in bridging it.

Figure 1. Osceola Lode open stope

Mining Methods in the Amygdaloid Lodes—

Osceola Lode Operations

By
Ocha Potter*
and
Samuel Richards†

THE Osceola amygdaloid lode has produced a total of 478,277,432 lbs. of refined copper from the beginning of operations to the close of 1929. During 1929 it produced 18,237,000 lbs., being exceeded only by the Calumet conglomerate and the Kearsarge and Baltic amygdaloids for that year. Although 12 shafts have been sunk in this lode along the three and three-quarters miles of strike contained in the lands of this company, only four are now producing.

The mineralization is very erratic. The most persistent copper-bearing horizon is along the hanging-wall side of the lode, but in many places rich pockets of heavy copper occur where irregular bunches of the fragmental amygdaloid extend deep into the underlying footwall trap. During and after the stoping of the more consistently mineralized hanging portion of the lode, it is necessary to carefully examine the floor of the stope for any indications of deeper copper mineralization. In some cases, following the most inconspicuous leaders may result in finding these rich footwall pockets. If there is a barren horizon of more than 4 or 5 ft. between the hanging stope and the footwall copper, it

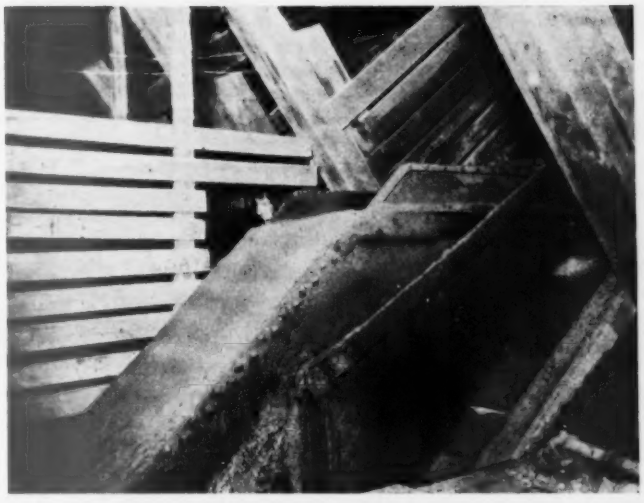


Figure 3. Standard skip, Osceola Lode

* Superintendent of the Ahmeek-Kearsarge Branch.
† Head Mining Captain on the Osceola Lode.

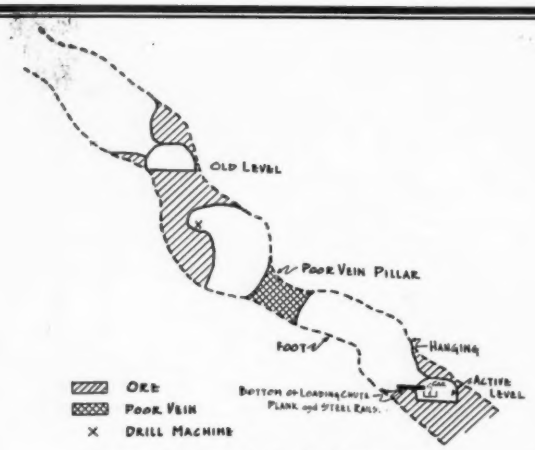


Figure 2. Osceola Lode Stope section through chute

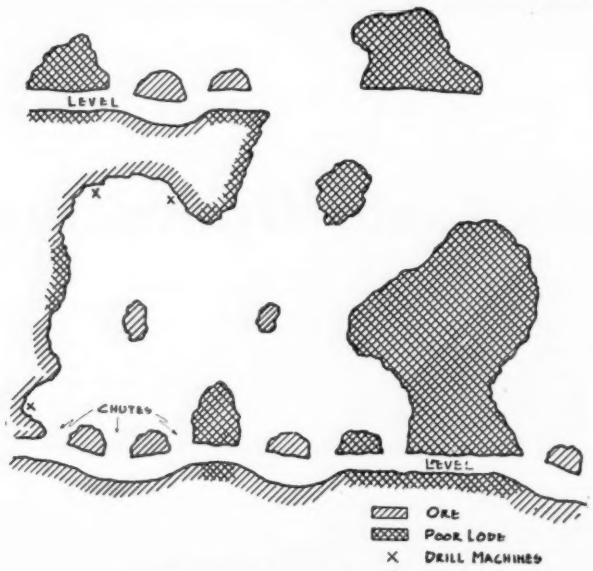


Figure 4. Osceola Lode Plan of stope

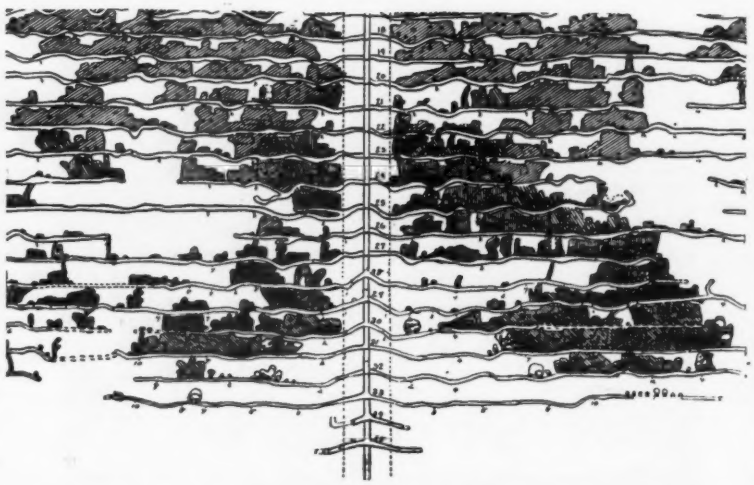


Figure 5. Plan of active workings in one of the Osceola Lode shafts

may be left in place while an independent footwall stope is carried up parallel to the hanging stope; otherwise the footwall copper is mined by jackhamering out the bottom of the hanging-wall stope. The most careful scrutiny of the ground exposed as development progresses and the closest attention to selective mining must be exercised; otherwise the lode would not yield even the expected average of nine-tenths percent copper. (See *Figures 1* and *2*, photo of open stope and sketch of a typical stope section.)

Shafts

The shafts are located in the vein preferably a few feet from the hanging-wall or just under the vein; then the level plats are only a little way in the hanging or wholly in the vein; but the lode is so irregular with its rolls and hollows that it is sometimes beneath or above the 37-degree dip determined upon as the average inclination to be followed in shaft sinking. Three of the four shafts now in regular commission have reached depths of nearly 4,500 ft. They are 9 ft. by 22 ft. and each has two hoisting compartments, one at either end, and a 4-ft. middle compartment for ladders, pipes, wires, etc. As yet there has not developed any necessity for continuous close timbering. Dividers of 12-in. by 12-in. fir set to 7-ft. centers are held in hitches cut in the rock; if loose ground is encountered which does not arch, wall-plates and end-pieces of the same material used for dividers are put in at intervals of 2 or 3 ft. and lagged with cedar flat timber and blocking. Skip-road tracks are laid with 60-lb. steel spiked to 7-ft. cedar ties 8 in. thick and 14 in. apart, much like any railroad. The gauge, however, is 5 ft., and just outside the rails 6-in. by 8-in. fir guides are securely fastened to the ties longitudinally and wedged against dividers or solid rock to help preserve the track gauge and keep the skip wheels from climbing the rails. Renewal of worn-out ties is readily taken care of and there is always available plenty of broken rock and fine dirt for tamping and lining up the track. The skips have a capacity of 7½ tons and are of the usual self-dumping type. They are built with the rear end lower than the rail-head and the front end considerably higher in order to make the skip body-pitch steeper than the track so as to facilitate loading. The rear wheels are on hubs riveted to the sides of the skip and the front wheels are on an axle beneath the body. (See *Figure 3*, photo of skip.) The skips operate in balance at a maximum hoisting speed of 2,800 ft. per minute. The average net load of

Figure 6. Standard 3¾-ton car and motor

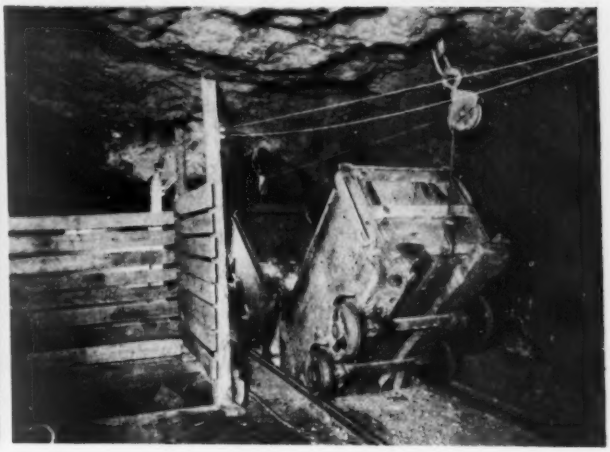


Figure 7. Dumping tram cars through chute

ore hoisted is 7 tons. For handling timber a timber-truck is substituted for one of the skips; while for lowering and hoisting men a special man-car with seats for 30 takes the place of the skip. Lilly hoist controls automatically limit the man-car speed to less than 1,000 ft. per minute and prevent over-hoists at any time by shutting the engine throttle and applying the brakes within a margin of safety.

Shaft pillars of 110 ft. on each side are left to protect the shaft. It may become advisable at greater depth to leave larger shaft pillars, but as yet no extreme pressure has been felt in them. Levels are spaced approximately 120 ft. apart, measuring down the shaft; trials with lesser and greater level intervals demonstrated some years ago that there were more reasons favoring 120 ft. than there were in favor of 100 or 150 ft. Plats are made large enough to accommodate the bulky objects that must be landed from the shaft, such as tram-cars, locomotives and long timber. When a new level is started, even if the plat does not happen to be ideally located owing to the irregularity of the lode, still the drifts are extended well into the shaft pillar on a line normal to the vertical plane of the shaft before they are curved right or left to the preferred position in the vein, i. e., just beneath the hanging-wall. They are made wide enough to take two tracks with cross-overs, switches and a siding to facilitate tramming and expedite skip-loading as each level becomes a producer.

Drifting

In lateral openings the cross-sectional dimensions found most convenient for all purposes and fixed as standard are 14 ft. wide and 8 ft. high, with the top corners slightly rounded. The hanging-wall stands up well and "cut holes" break freely on that side. Furthermore, it is almost invariably the case in the Osceola lode that the copper is encountered in the upper part, if present at all; hence it has become standard practice to drive the drifts close to the hanging and to use the side cut. Two miners are given a contract running one month for each heading; the price set covers drilling, blasting, breaking blockholes and barring loose, the explosives and certain specified small supplies being charged to them and everything else being furnished by the company. One miner works day shift and the other at night with muckers or trammers present to clean up the ore broken at the end of the previous shift. The cut is drilled and blasted first; for a complete round about 30 holes are required to gain an average advance of 4¾ ft. per day. The levels resulting from this method of opening are, of course, very crooked. The frequent rolls in the vein cause many sharp turns in the drift, and the tram tracks when first laid must necessarily follow all the turns and twists; but in spite of the very evident disad-

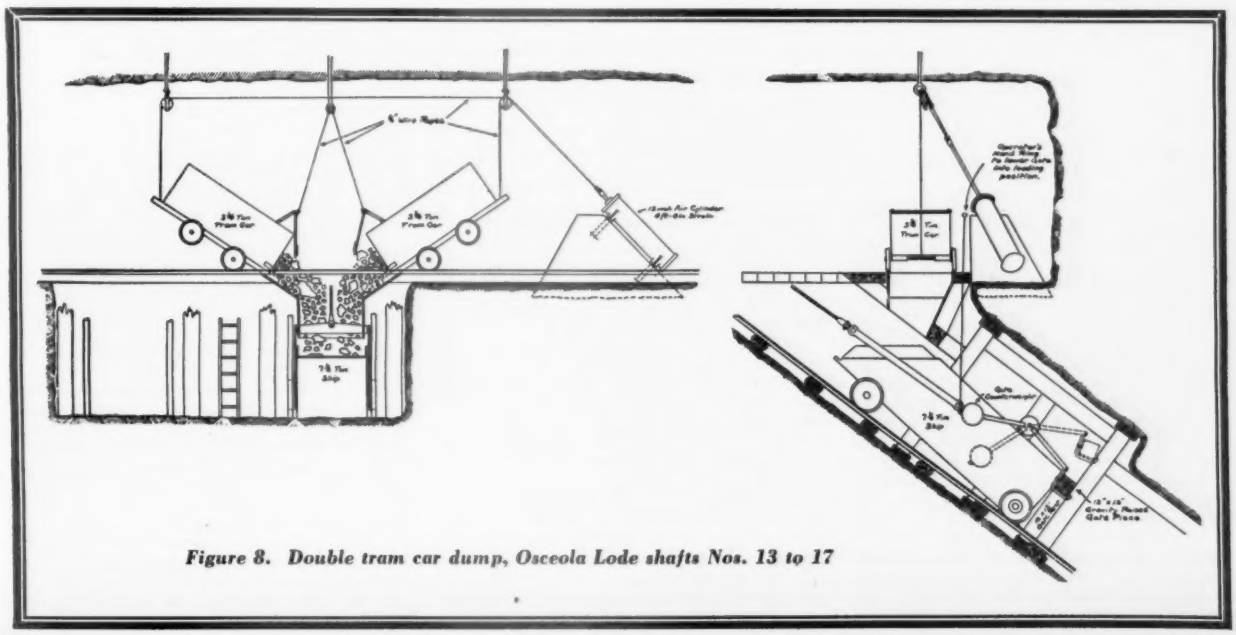


Figure 8. Double tram car dump, Osceola Lode shafts Nos. 13 to 17

Figure 9. Scraping through chute

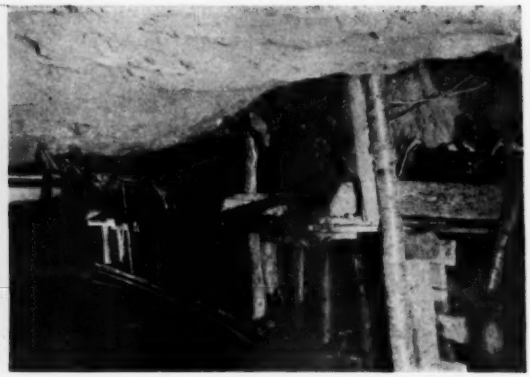


Figure 10. Standard stope chute

vantages attached to this practice, in the long run it proves to be the best for all purposes with the exception that scrapers or other mechanical loaders can not be adapted to the very unsuitable conditions prevailing.

Gelatin 40 percent powder breaks the vein effectively and gives a minimum of fumes. Ordinarily no mechanical ventilation is required unless an unusually long drift is in progress, and it is very seldom that any timbering is necessary in new openings.

Stoping

Open stopes with pillars and without timber are the general rule in the Osceola lode, but any systematic prearrangement of pillar size and location is, to a large extent, impracticable. Sometimes the hanging-wall comes over towards the foot and lies almost horizontal; elsewhere it rises vertically for 30 or 40 ft. A section of stoping ground normal in dip and width and well mineralized may end abruptly against a bar of trappy vein, hard and barren, with no indication as to how far it may be necessary to go before finding copper again. It is not uncommon either to follow a stringer of ore towards the foot and come into a pocket wholly beneath the stope already worked out on the hanging-wall side. Stope pillars are necessary, but experience and good judgment must determine their location; barren or lean vein is chosen whenever possible. (See sketch plan of stope, *Figure 4*, and photo *Figure 1* and map of active workings, *Figure 5*.)

The Osceola lode is not as hard as the Kearsarge or the Conglomerate but is tougher and of a "rubbery" character that makes it more difficult to break. For a given stope face or a required tonnage more holes must be drilled and more explosives used than is the case in the other lodes. Ingersoll-Rand N-72 machines are standard equipment while Jackhamers are used for underhand stoping in footwall pockets, for trimming and for block-holing. Drills are made of 1-in. hexagon, hollow steel without lugs or collars. The starters and seconds have cross-bits but all the longer steels up to 12 ft. have single bits; the starter gauge is 1 9/16-in. and each succeeding change is 1/16-in. less. Sharpening drills is not a great item in the mining costs of this lode, for only seven or eight bits are dulled for each machine-shift. Stope miners work under a bonus system with a minimum wage; each man is expected to accomplish 50 ft. of drilling per day and is urged to earn extra pay for extra footage. The holes are measured by a foreman near the end of each shift and they must be so placed as to meet with his approval. Atlas Special No. 3 powder has been found to give the best results in this ground and has been adopted as standard. Machines, explosives, tools and all requisite supplies are furnished without cost to stope miners who are entrusted with the responsibility of charging and blasting their rounds of holes, barring down the loose and breaking the big pieces of ore to a size that the trammers can handle. The effectiveness of the stoping system described is attested by the fact that the average quantity of ore procured from the stopes is well over 25 tons per miner's shift.

Tramming

In the drifts 2½-ton cars are used for hand loading and pushing. The outer end of each car has a full-height door hinged at the top; the inner end has a low door hinged on the bottom edge to open down and serve as an incline when the trammers have big pieces of ore to load by rolling them into the empty car. Also, the door when closed and fastened is not too high for shoveling over it from the ore pile at the breast of the drift. As stated before, scrapers and mechanical loaders have been thoroughly tried without being found economically successful for this work. The quantity of ore to be loaded at one time is too small—never more than 25 or 30 tons. Besides, the crooked drifts offer so much interference that the simple system of hand and shovel work remains the best and cheapest under the circumstances. Three of these cars are dumped into the skip for a load.

On the production levels larger cars are used having a capacity of 3¾ tons. (See *Figures 6* and *7*.) They are dumped two at a time by means of air-lifts through a chute between the rails. The skip is held on a gate at exactly the right spot beneath the chute so that spillage is avoided and the load, discharged from so great a height, slides well down into the skip body. (See *Figure 8*.) Ore is loaded into the cars through stope chutes either by gravity only or with scrapers. (See *Figures 9* and *10*.) Chute holes are cut horizontally toward the footwall about 4 ft. above the track; they are 9 ft. long by 5 ft. high and are usually spaced 25 ft. apart. The timber-work is simple and inexpensive, no large members being required; the bottom is lined with old rails and hardwood plank. The scrapers are 4 ft. wide and are operated by double-drum air-engines or electric hoists with ½-in. wire rope. Three-ton chassis, storage-battery locomotives are used on production levels; the longest haul is 2,500 ft. and the average is about half that much. Trammers are expected to load, haul and dump a certain number of cars for a minimum or "company account" wage; for all cars over the base requirement they are paid a bonus. In actual practice more than half of the trammers are bonus-earners and they handle considerably more than half the ore. The rest is loaded by hand-shoveling in drifts and in cleaning up; but all the trammers combined attain a high average figure for this class of work, i. e., nearly 25 tons per shift.

General Remarks

Compressed air at three of the shafts operating is maintained at a pressure between 70 and 75 lbs. At one shaft a booster compressor raises the pressure to over 100 lbs. The drilling speed of the machines running with such high pressure is considerably increased, but breakage of machine parts and drill steel is likewise materially greater. The average efficiency measured in "tons per man per shift" for the underground force in this mine is now the highest in all the Calumet and Hecla group and has been very high over a long period. Figured monthly it seldom falls under 7 tons and some months it goes over 8.

The operating staff consists of a general foreman called "the captain" and an assistant foreman; at each shaft there are two shift-bosses on opposite shifts and each of them has two assistants or trammer-bosses. No considerable organization of timber crews is required. The stopes stand open usually long enough to get all the ore except the pillars, and in some cases the best of them are salvaged at the last. No serious crushing and no rock-bursts add to the ordinary difficulties of operation. There is very little water to be handled and most of that is conducted through hanging-wall crosscuts to the Conglomerate workings where extensive pumping equipment is provided, as described in other papers in this series.

SHRINKAGE STOPING

in Amygdaloid Lodes

By A. H. Wohlrab*

THE Isle Royale mine, located in Houghton County about a mile south of the village of Houghton, is one of the subsidiary mines of the Calumet and Hecla group. It is opened along the strike of the Isle Royale lode for a distance of nearly three miles. There are six inclined shafts—three operating—sunk on the dip of the ore body or as nearly thereto as possible, and spaced at irregular intervals varying in distance from about 2,000 ft. to over 4,000 ft. The general arrangement and equipment of surface plants is similar to the more or less standardized type common among the properties in the Calumet district, which are fully described elsewhere in this series of articles on the Calumet and Hecla Consolidated Copper Company. The distinctive feature of the Isle Royale property is that the ore body is mined by the shrinkage stoping method, that is, by overhand stoping with the broken ore used as a working floor and only enough ore being drawn off to provide proper working space for the miners.

The lode occurs as the fragmental top of a lava flow, which has an average thickness of about 75 to 80 ft. The form of the lode is tabular; it dips 56 degrees, and the thickness varies from 0 to 15 ft. or more, with an average stoping width of about 9 ft. The ore and wall rocks are fairly strong and firm over limited areas; but where minor cross-faulting and cross-fissuring occurs, this is not the case. However, by means of a judicious selection and concentration of pillars, the hanging-wall is strengthened and the dilution of ore with waste from caving is kept at a minimum. Mineralization of the lode is not uniform, so that even where the walls would allow continuous stoping it is found necessary to leave poorer portions, thin lode, as pillars. Occasionally blocks of 50 to 100 ft. or more in length are left in place because the surrounding openings indicate that they are thin lode areas and too poor to mine. This selection results in keeping the grade of ore mined at eight-tenths to nine-tenths percent copper. By further selection of the broken ore in the rockhouse, the grade is raised to about one and one-tenth percent copper.

Prior to 1913, the advancing method of shrinkage stoping was employed at this mine; but at a depth of about 2,500 ft., the cost of maintaining safe haulage levels became so great that it was found advisable to put all stoping operations on the retreating system. The three operating shafts are now down to a depth of nearly 5,000 ft. on the dip of the lode, and it has not been found necessary to modify this method.

The shafts, which are three compartment, are equipped with two 7½-ton skips operated in balance at a maximum rope speed of 3,400 ft. per minute. The load per skip is five tons. By having the skip about one-third larger than is required for the load, the use of skip gates to prevent rock spillage, caused by rope stretch when loading, is avoided and faster loading is obtained. Plough steel ropes 1⅜ in. in diameter, 6 strand, 19 wires to the strand, with hemp center, are attached to the skips with socket and clevis. For handling all timber and supplies, a timber truck is put on in place of one of the skips. Likewise a man-cage, with a capacity of 30 men, is substituted for a skip when handling men on or off shift. The maximum speed for handling men is 850 ft. per minute, both skip speed and man-car speed being regulated by Lilly hoist controls. Skip roads are 4 ft. 6 in. gauge, laid with 45-lb. A. S. C. E. steel rails spliced with angle bars and spiked to 8-in. by 12-in. by 22-ft. stringer timbers. The third compartment of each shaft is used for a ladder way, air lines, electric power and signal lines, pump discharge columns and telephone wires.

Sinking

Sinking operations are carried on under a rock pentice while the shaft is operating, and about 250 ft. are sunk with each set-up of equipment. The sinking outfit consists of a geared, single-drum hoist with friction and multiple gear arrangement for fast lowering, a ½-ton or 10-cu. ft. bucket, 10-in. I-rails, a trolley and ¾-in. hoisting rope. The I-rails are suspended from the hanging-wall timbers with chains at 10-ft. intervals.

Broken rock is shoveled into the bucket by hand, hoisted with the trolley traveling on the I-rail to the level above, and dumped into a 5-ton car. This in turn is dumped directly into the skip by means of a 13-in. air lift. The sinking crew consists of two machine men, one mucker, one timber-boss, four timbermen, a top-man and an engine-boy on the day shift; or three muckers, a top-man and an engine-boy on the night shift. The mining is done on contract. The company supplies drilling machines, mountings, drill steel and air, while the miners are charged at cost for explosives, fuse and certain other supplies. Drilling machines of the C. P.-6 or Denver-7 type with standard 3-in. single-jack posts and mountings are used. The night shift muckers work on a bonus system, and whatever rock is left in the shaft at the end of the shift is mucked out, on company account, by the day shift muckers. The timbermen also work on a day rate and, if necessary, help the day shift mucker clean up the remaining rock. The size of the shaft is 10 ft. by 20 ft. clear of the timber, and the rate of advance is 45 to 50 ft. a month. Stations are cut every 125 ft., which is the level interval. The hanging-wall timber is kept within a few feet of the working face to protect the miners and muckers from exposure under a freshly blasted back; the completed shaft timber follows along with the sinking operation but 40 to 50 ft. up from the working face. With the exception of the stringer timbers, which are of southern pine and creosoted, all of the shaft timber is flat cedar. This is used because of its superior decay-resisting qualities and its moderate cost. (See *Figure 1.*)

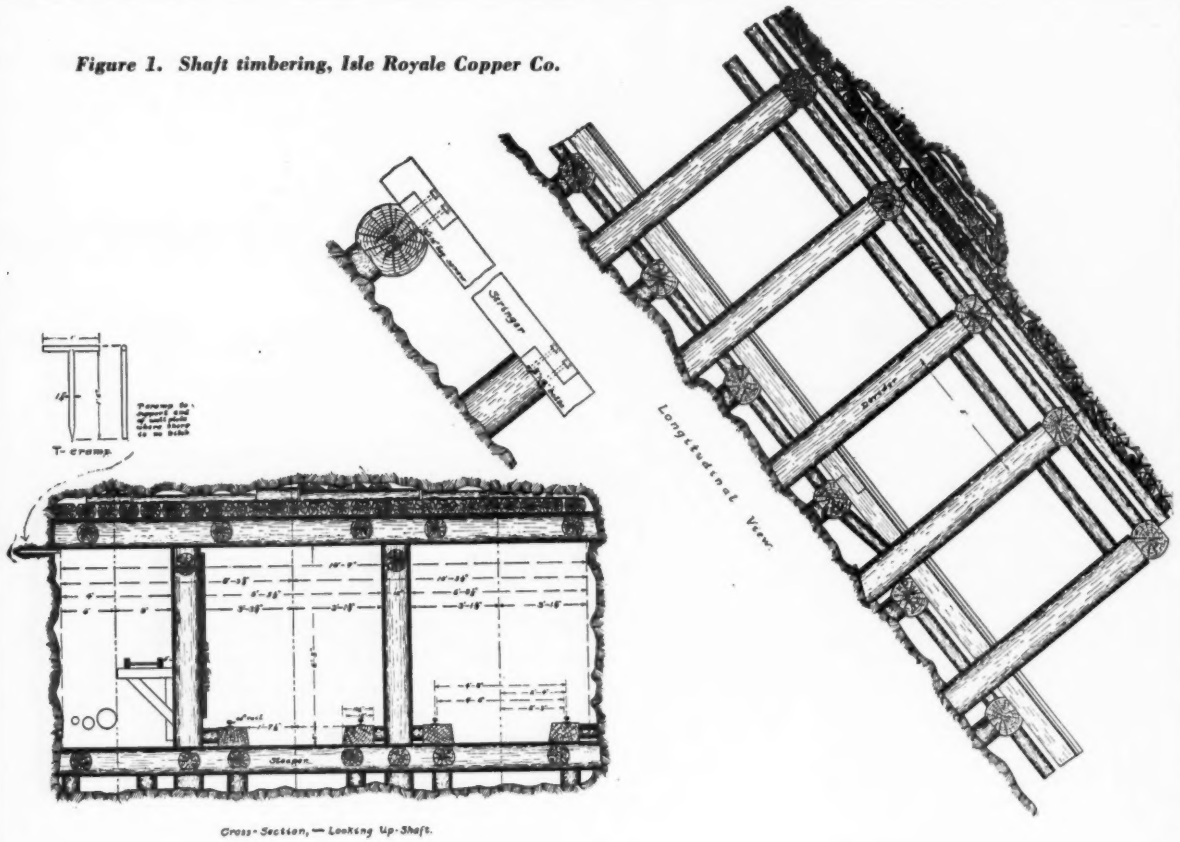
Lateral Openings

The drifts that form the haulage levels are driven out to the prescribed boundaries on either side of the shaft, after which stoping operations may begin, provided that stoping on the level above has already begun and is on the retreat toward the shaft. After a number of levels have been started, the working faces are arranged in steps down and outward from the shaft, as shown in *Figure 2.* Drifting is kept well in advance of stoping so that, after a stope has been completed at the shaft pillar, a new stope can be started at the shaft boundary five or six levels below.

Because of the spotty, non-uniform mineralization of the ore body and because all the rock that is broken is hoisted to the surface, selective mining in place is employed in all drifting and stoping operations. Development openings are in the lode, along the foot-wall side, and are driven as 7 by 7-ft. drifts or as 9 by 18-ft. drift-stopes, depending on whether thin lode material or copper

* Superintendent of Isle Royale Copper Co.

Figure 1. Shaft timbering, Isle Royale Copper Co.



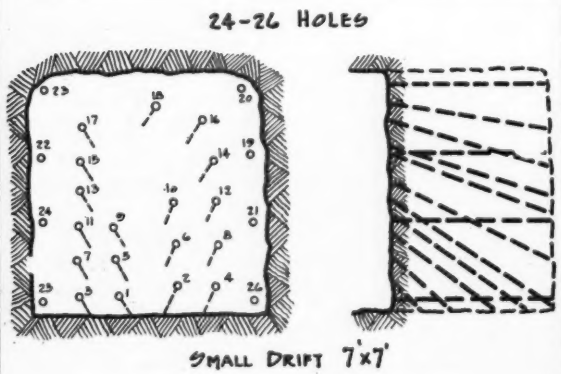


Figure 3. Drift Round

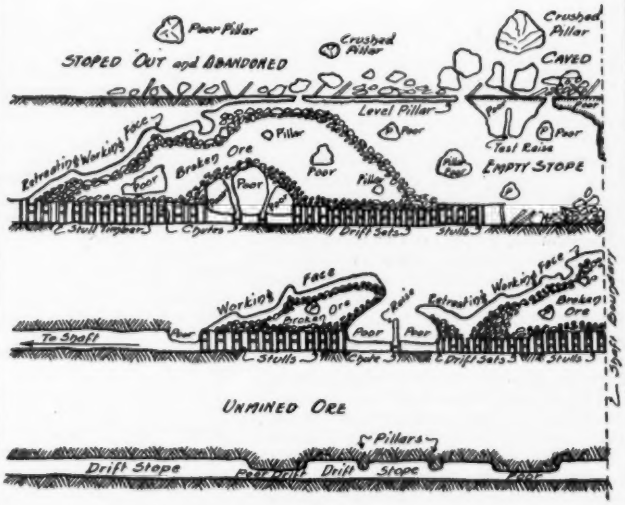


Figure 2. Shrinkage Stoping

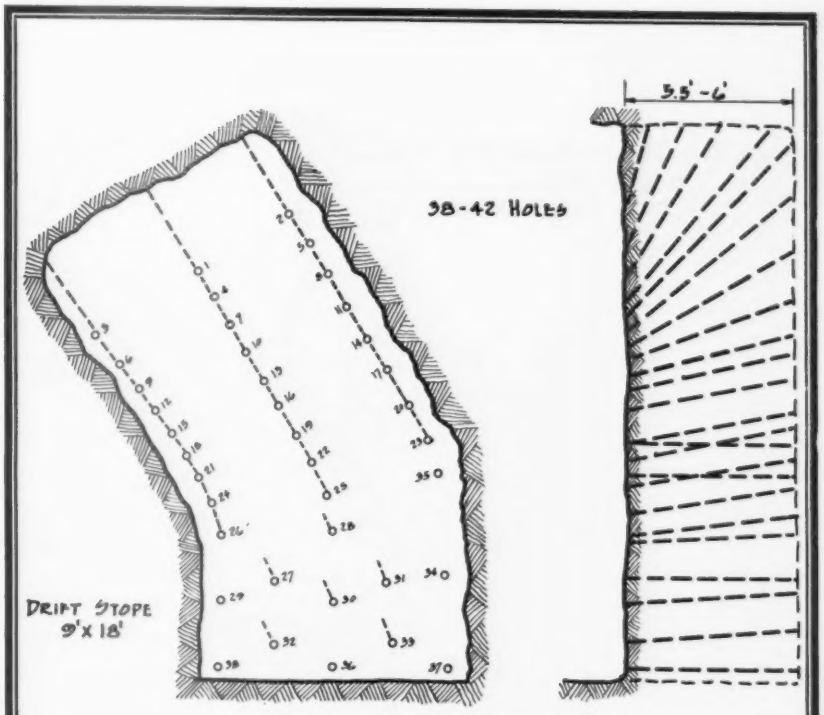


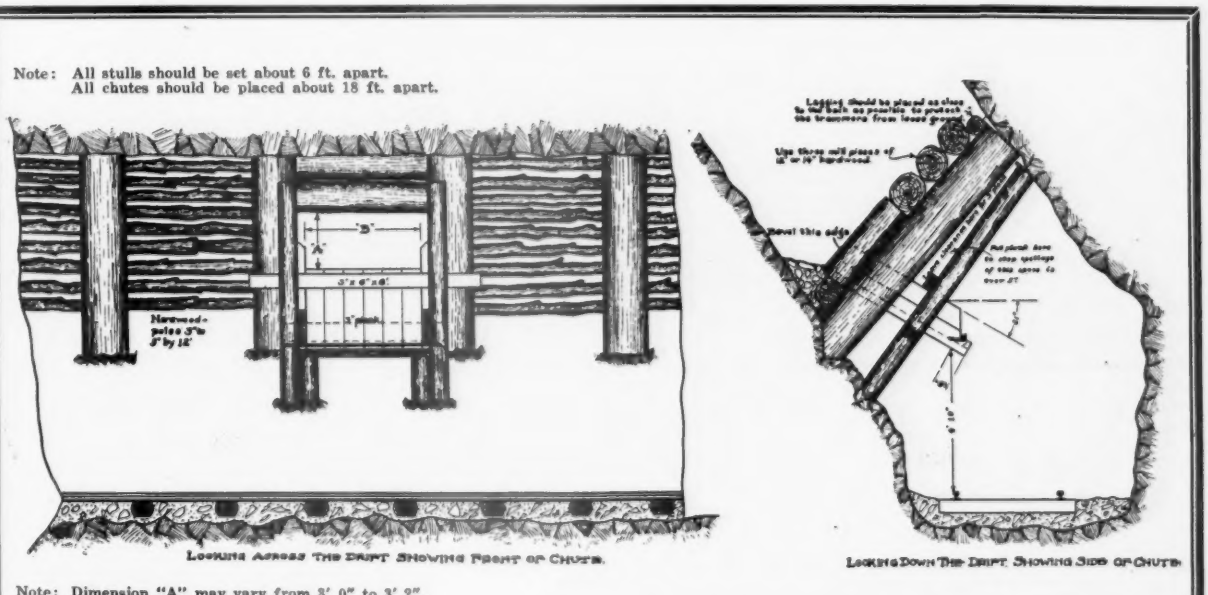
Figure 4. Drift Stope Round

is encountered. In advancing development openings, the drift or drift-stope cross-sectional area is rigidly maintained even though the drift-stopes frequently encounter conditions indicating a widening out of mineralization that might easily be recovered at the time. Such recovery would, however, seriously interfere with the miner's contract and the continuity of development progress, would necessitate long-time maintenance of the widened openings with consequent high timber charges, and would generally disrupt orderly procedure throughout. Drifting is done on contract with a separate rate for each of the two cross-sectional areas mined, and the rate is so adjusted that there is a slight advantage to the miners when driving the larger openings. The miners pay for explosives and certain other supplies at cost, while materials such as drilling machines and mountings, similar to those used in sinking operations, are supplied by the company. A drilling crew consists of two miners who rig up their machines, drill and blast, at the end of each shift, a 7 by 7-ft. drift round of 24 to 26 holes with an advance of 4½ to 5 ft. per round; in a drift-stope they blast a round of 38 to 42 holes every second shift with an advance of 5½ to 6 ft. per round. *Figures 3* and *4* show typical rounds. Drifting advance is measured at the end of the month, and if the miners fail to "make contract" they are paid off at the company account miner's rate.

With the exception of an occasional prop to support loose ground, very little timber is used in development openings.

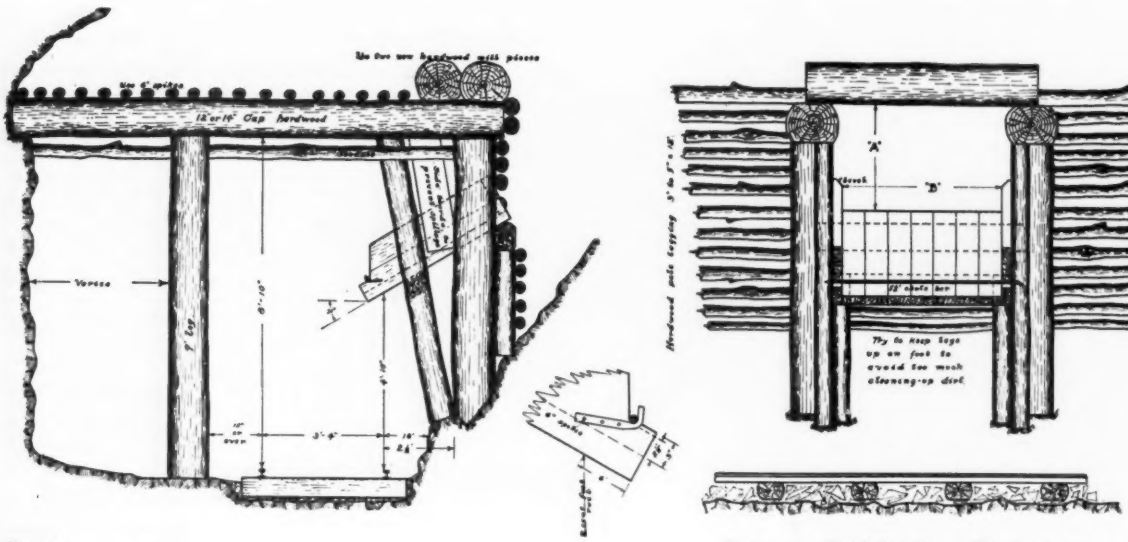
TIMBERING

After the boundary limits have been reached in development operations, the ore body is opened out to its full width in the direction of the shaft for about 100 ft., unless this condition has already been obtained in the drift-stoping operation. Stull timbering is normally employed; but if the width of the lode that has been cut out exceeds 12 ft., drift sets are used. (See *Figures 5* and *6*.) The stulls or sets are put in on 6-ft. centers and chutes are built about 18-ft.


Note: All stulls should be set about 6 ft. apart.
All chutes should be placed about 18 ft. apart.
Hardwood-poles 5" to 8" by 12'
Looking Across The Drift Showing Front of Chute.
Looking Down The Drift Showing Side of Chute.

Note: Dimension "A" may vary from 3' 0" to 3' 2".
Dimension "B" may vary from 4' 6" to 4' 8".
Bottom chute planks 3" x 6".
Side chute planks 3" x 8".
Use 10" spikes in chute planks.

Figure 5. Isle Royale Copper Company Standard Chute for Slopes



Chutes:
Use 3" x 8" hardwood.
Use 10" spikes.
Use 5 ½' cnute bar.

Chute openings:
"A"=3' to 3' 2".
"B"=4' 6" to 4' 8".

Figure 6. Drift-Set Stope Timbering

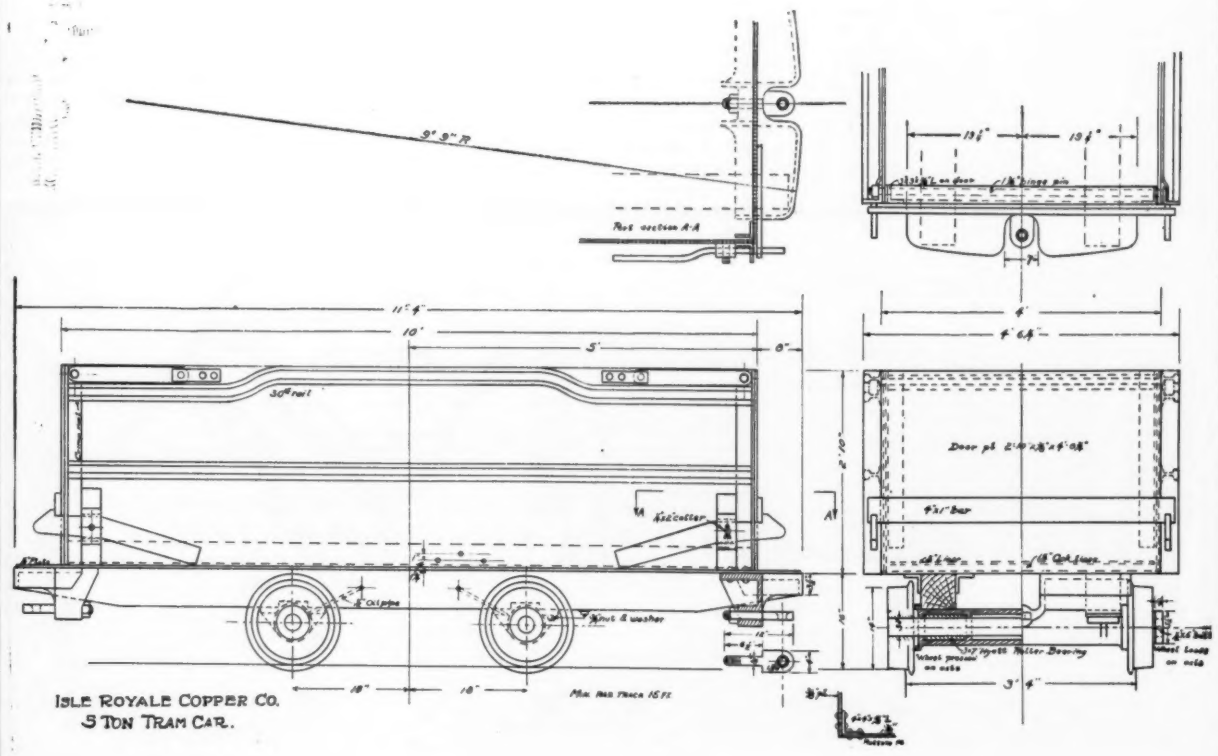


Figure 7. 5-Ton Train Car, Isle Royale Copper Company

apart. Green maple or birch poles 3 in. to 5 in. in diameter by 12 ft. long cover the stules or sets; and two or three large diameter hardwood mill pieces of green timber, capable of resisting the constant blasting by the trammers, are put over the chutes. The chutes, as shown in *Figures 5* and *6*, are made sufficiently large to allow the passage of big chunks of ore with a minimum of blasting by the trammers. The tram cars (See *Figure 7*) used in loading operations are also of liberal dimensions; they are wide enough to stop the flow of ore from the chute as the car becomes filled, thus preventing spillage over the side.

Stoping

After the timbering has been completed, stoping operations are started by two men with two machines rigged on top of the timbers at the boundary limits. The timber is covered and, by means of a series of inclined slices, the stope is worked through to the level above. A third machine, which later is put on regular stoping operations, is first used to cut out on the level for the further extension of timber in the direction of the shaft. The stope face now extends up the dip of the lode toward the level above and along the level in the direction of the shaft, as shown in *Figure 2*. The length of the working face depends largely on the condition of the hanging-wall. If the indications are that a stope will not stand open over a long period of time, a short working face is preferred because a given section of ground can be mined out and abandoned more quickly in this way. In general, however, the working face is kept long, forming an angle of 30 degrees or less with the level. This makes better rigging for the miners, and it is easier to follow the irregularities of the ore body on the foot-wall side. Unfortunately there is no practical method of sampling native copper ore; hence, as stated before, considerable attention must be given to selective mining in place, all poor ground being left as pillars. The lode and the foot and hanging-walls are constantly scrutinized by the foremen, and their observations are supplemented by further studies with raises, crosscuts and test holes. Only enough of the broken ore is drawn off through the chutes to give proper working space for the miners. When stoping operations have advanced far enough ahead of the filled stope to allow complete removal of the broken ore, the drawing off must be done systematically so that the trammers are not unnecessarily exposed to the open stope. Normally, unmined pillars tend to retard a too rapid collapse of the hanging-wall, and it is possible to salvage the rails and some of the timber.

Stope miners work on a bonus system, the wage depending upon the footage drilled. They receive company account miner's pay for a certain fixed number of feet drilled per shift, after which a bonus is paid for all additional footage. It is required, however, that the placement of holes shall meet with the approval of the shift boss who measures the number of feet drilled at the end of each shift. All mining equipment, explosives and other supplies are furnished by the company; thus the miner can readily figure his pay at the end of every shift. Each miner rigs up, drills and blasts his own round of holes and is held responsible for all loose ground and whatever blockholing may be necessary in the stopes. A Jackhamer is supplied to each party of two or three miners for this work. An average shift's drilling amounts to about 60 or 65 ft. and the average depth of hole is 7½ to 8 ft.

Tramming

All tramming is done on a bonus system. The trammers receive company account trammer's pay for a certain fixed number of cars of ore delivered into the skip, after which a bonus is paid for each extra car. The bonus per car depends upon the accessibility of the ore and the method of loading, that is, whether it is shoveled or loaded from chutes. Tram cars, both on production and development levels, are 5-ton, 104-cu. ft., roller bearing equipped, end-dumping cars with trucks bolted to the body. (See *Figure 7*.) They are dumped at the shaft by means of a 13-in. air lift through a chute between the rails in back of the plat, or from a tipple placed at either end of the plat. As the tram-car load and skip load are the same, the dumping time is usually not more than 20 seconds.

In general, motor haulage is used on production levels and mule haulage on development levels except where drifting has not advanced far enough from the shaft to permit the stabling of a mule. Here hand tramming with 2½-ton cars is used temporarily. Mechanical loading or scraping has not been found economical in drifts of small cross-sectional area and is not being used in this mine.

Steel rails weighing either 35 or 25 lbs. per yard are employed in ore haulage. The 25-lb. rails, however, are a relic of hand tramming days and are being gradually discarded. Wherever spreading of the light rails occurs, steel mine ties are used to good advantage. The gauge of the tracks is 40 in.

Ventilation

There is a very pronounced movement of air between shafts on the operating levels; and consequently it has been found unnecessary to resort to mechanical ventilation except in special cases. Since the stopes are generally open at both ends, they are well ventilated by the air movement along the levels. The ventilation on the operating levels is aided by closing the draft or fire doors at the shaft on the upper levels where stoping has been completed. In the dead end of the long development drifts, however, mechanical ventilation must be employed. For this purpose either the American Blower Company's No. 5 high speed or No. 4 special ½-width Anaconda-type fans are used, with 16 and 12-in. diameter Ventube to conduct the air to the working face.

General Remarks

Air pressure of 80 to 85 lbs. is maintained at the drilling machines. Anvil block machines of the C. P.-6 or Denver-7 type with 3-in. single-jack posts and mountings are standard equipment for all stoping, drifting and sinking operations. Line oilers are used on all machines. Braided 1-in. air-hose with oil-resisting inner tube and ½-in. water-hose are used with the machines.

Two sizes of hollow drill steel are standard: 1-in. hexagonal for general mining operations and ⅞-in. hexagonal for Jackhamers, which are used for blockholing. The ⅞-in. hexagonal steel is gradually being replaced by the 1-in. steel, which will soon become standard throughout the mine.

Double-taper cross bits are used for starters and second drills after which a double-taper single bit is used. Starters are 3 ft. long with 1 9/16-in. gauge. The drill change is 22 in., the difference in gauge is 1/16 of an inch, and there are six changes, thus making the longest drill 12 ft. 2 in.

In stoping and drifting operations 70 percent Coalite "A" powder is used. The drift miners in general use a few sticks of 50 percent giant gelatin, low-freezing powder at the bottoms of the holes to help bring out the cut. In the shaft 60 percent ammonia, low-freezing powder is used.

Electric power for motor haulage, hoists, pumps and fans is transmitted underground as 2,300 volts, 60-cycle, alternating current and is transformed to 440 volts for general power purposes. All pumping is done electrically in stages, varying in distance from 200 ft. to 1,200 ft., depending upon conditions. Both horizontal and vertical plunger pumps of various makes are in use.

Twenty-five horsepower motor-generator sets supply direct current for storage battery motors, one set meeting the requirements of two levels.

Ninety to 95 percent of the ore mined is hauled by 12 3-ton chassis, Goodman storage battery locomotives and 16 mules. The remainder is hand trammed.

Mining Methods used

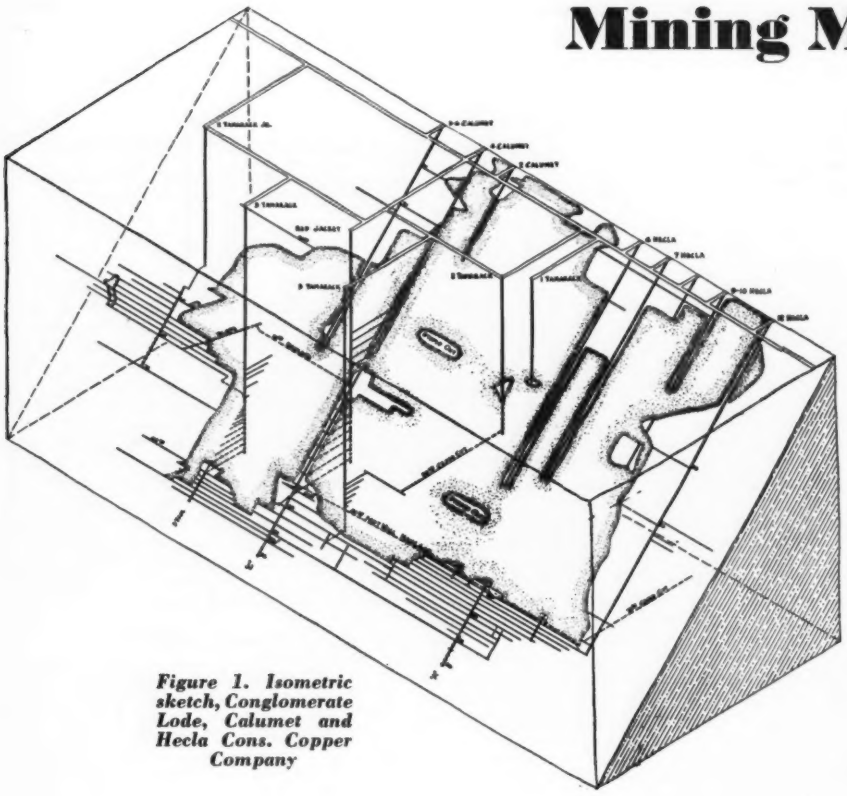


Figure 1. Isometric sketch, Conglomerate Lode, Calumet and Hecla Cons. Copper Company

By Harry Vivian†

THE Calumet Conglomerate Lode was discovered by an observing road surveyor, E. J. Hulbert, in 1858. A mass of copper vertigris found in a pit, where it had presumably been hidden a great many years before by persons preceding him into that heavily wooded district, caused him to make a thorough reconnaissance of the surrounding areas which resulted in the discovery of the most famous native copper bearing lode in the known history of the world.

Physical Characteristics of Lode

The orebody occurs in a felsitic conglomerate traceable for a great many miles but, in most places outside of the Calumet & Hecla property, found as a thin sandstone, in many places being but a few inches thick. At Calumet the bed is from 10 to 12 ft. in thickness near surface, widening out to about 20 ft. at the eighty-first level, which is 8,100 ft. below surface along the dip.

The conglomerate bed is of a reddish color and lies interstratified with the darker colored volcanic rocks of the Keweenawan Series, being overlain and underlain by thick beds of trap. The pebbles of the bed are composed of felsite and quartz porphyry and are cemented together by small particles of sand, quartz, calcite and native copper, the rocky particles in the cement being similar in composition to the pebbles, which vary in size from a fraction of an inch to boulders a foot and more in diameter. The rock has a general hardness of 7 and is highly abrasive and tough. The copper occurs chiefly in the filling between the pebbles or as part of the cementing material, although it is not uncommon to find pebbles partly replaced by native copper and frequently fine copper occurs within the pebbles themselves. The general strike across the Calumet property is N. 33 E. with decidedly little variation and the lode dips to the northwest at an angle of approximately 38 degrees below horizontal at the surface, flattening to about 36 degrees at a depth of over a mile vertically.

Within the conglomerate there are frequently found layers of sandstone, lenticular in form as a rule, but quite often of considerable extent. These streaks or beds, greenish gray in color, while they are commonly barren of copper themselves, usually occupy a position between the commercially mineralized portions of the lode and must be broken with the vein material. The well-marked parting along the bedding of the sandstone requires special attention in placing timber supports.

The entire hanging trap is checkered with slips or jointing faces at various distances apart, nearly all of which are tight and dry. Few shatter-zones exist, but in places the slips are grouped thickly.

The foot-wall is a very highly fragmental amygdaloid forming the capping of the underlying trap. It is non-commercial and contains a large proportion of the softer minerals, such as calcite and chlorite, together with a fine shaly sand, being in contrast in this respect with the extremely hard conglomerate vein above. When weight of the hanging, over any considerable area, is allowed to concentrate upon unmined pillars of vein the result is likely to be disastrous due to the thrust of this hard vein upon the weaker foot material below, causing it to bulge and frequently burst upward into the drift opening or shaft. This condition was of great influence in deciding upon the adoption of a retreating system of mining at depth.

Explorations Outside the Boundaries of the Calumet and Hecla Company

Strangely enough, the extent of the outcrop lying within the Calumet property, about 2 miles long, covers the only portion of this bed that has been found, up to this date, to be commercial. Starting at a vertical depth of 2,300 ft., however, a narrow, irregularly shaped area, formerly owned by the Tamarack Mining Company, runs down along the vein approximately through the center of the Calumet & Hecla property. This area, opened by five vertical shafts, was worked with profit by the Tamarack Mining Co. from 1887 to 1907 by an advancing room and pillar mining method, but was finally discontinued because of high recovery costs resulting from declining vein content and heavy timber charges. The land was acquired by the Calumet & Hecla Company in 1916, making it possible to connect the Calumet mine and the Hecla mine workings, which theretofore had been operated as two separate mines below the depth at which the Tamarack areas intervened.

Along the north boundary of the Calumet ore shoot two companies made unsuccessful attempts to find commercial mineralization. The Centennial Mining Company sank seven inclined shafts, one over 3,200 ft. deep, along the lode. Development and stoping were carried on extensively. A surface plant, including a mill, was built and hopes ran high at times over a period of 29 years. However, as no profits could be made, the property was closed permanently in 1898. The Tamarack Junior Company sank two vertical shafts, one 3,150 ft. deep and the other 3,206 ft., both through the

* The description of deep mining methods on the Conglomerate lode contained in this paper is printed by courtesy of the U. S. Bureau of Mines for whom it was recently written.

† Chief Engineer.

on the Calumet Conglomerate Lode*

overlying traps. After reaching the vein a considerable campaign of development and stoping was carried on, all with negative results. At the south boundary the Osceola Mining Company sank several shafts and drove a considerable number of exploratory openings; but after several years of work, this property was also closed permanently.

Production

Actual mining operations started in the year 1866 and, with the exception of forced temporary shut-downs due to mine fires, adverse metal conditions, etc., the mine has been a continual producer to the present time. The mills have treated 60,706,000 tons of ore from which 2,997,000,000 pounds of refined copper have been obtained, showing an average recoverable content of 49.3 pounds of refined copper for the entire period. The richest material was found in the upper areas of the mine and the copper content remained well above 90 lbs. per ton for the first 20 years of operation, gradually declining since then to the present content, approximately 40 lbs. per ton.

Development by Shafts

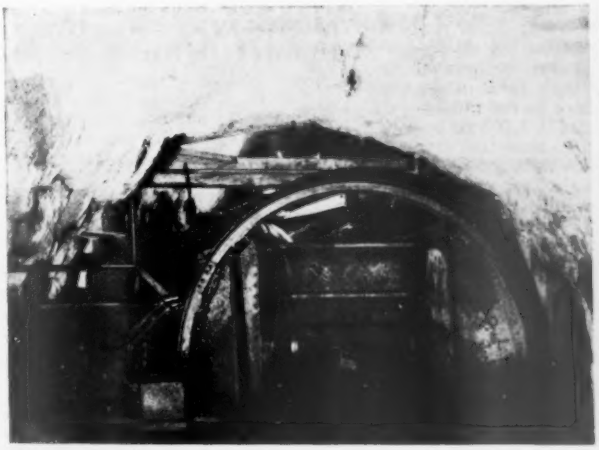
At Calumet the lode was originally developed by 18 inclined shafts spread over a distance along the outcrop of about 10,000 ft., the distance between the shafts varying from 450 to 1,100 ft. Five of these shafts were continued to or below the eighty-first level. The others were either abandoned, as mining experience developed and tramming facilities permitted longer haul, or were cut off when they reached the Tamarack boundary. (See Horizontal Plan of Mine, *Figure 1.*)

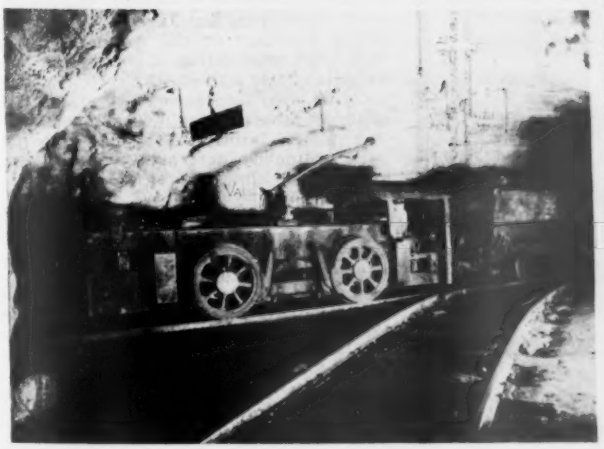
With the single exception of No. 12 shaft at the extreme southern end of the property, all inclined shafts are now being gradually abandoned by pillar removal operations above the eighty-first level, which has become virtually the top of a new mine in process of development.

The Red Jacket shaft, the only vertical shaft sunk by the Calumet and Hecla Company, intersects the lode just above the fifty-seventh level at a vertical depth of 3,270 ft. and has been extended to a

Figures 2 and 3, below, show respectively air operated dump cradle and locomotive and cars at 81st level.

At right, Figure 5 shows standard timbering, lower portion of stope.





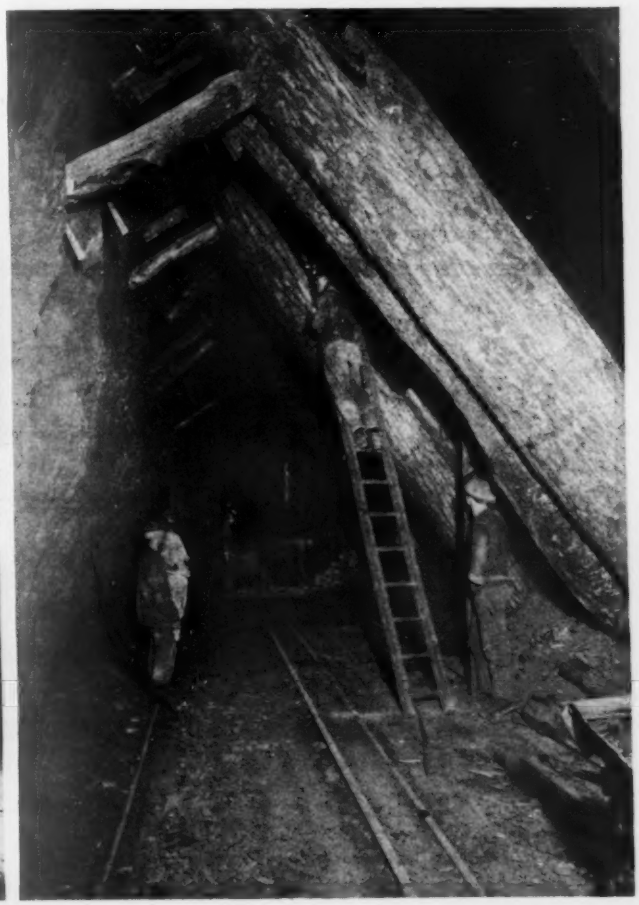


Figure 6, Showing "Breaker Row"

Figure 8. Shaft timbering and hanging at edge of pillar-removing stope.

point just below the eighty-first level, a total depth of 4,900 ft. (See *Figure 1*, Horizontal Plan of Mine.) This is the principal production shaft at present and is described in detail in a separate paper. It is connected to the vein by cross-cuts of about 7 ft. by 8 ft. cross-section on every third level from the thirty-sixth to the eighty-first. On the fifty-seventh level a foot-wall drift 2,600 ft. long was driven northward to the head of a sub-shaft, which was sunk in the foot-wall, about 90 ft. from the vein, on a dip of 22 degrees below horizontal. The shaft alignment rakes 55 degrees from a line normal to the strike permitting it to traverse the long dimension of a strip of territory consisting of five 40-acre pieces owned at this point. The track gauge in both the sub-shaft and foot-drift is 4 ft. and tram cars of 2½-ton capacity are hauled to the shaft on the various levels and handled on their own wheels through the shaft by an electric hoist.

Next in its importance to present operations is the Tamarack No. 5 vertical shaft, also described in another paper. This shaft is used as the main pump shaft for the deep areas of the entire mine and is connected to the vein by cross-cuts at various points down to and including the eighty-first level.

No. 3 Tamarack vertical, 5,222 ft. deep, connects with the vein by cross-cuts and is used principally as a pump shaft and for handling supplies to the mining area adjacent to the foot shaft just mentioned.

Development Below Eighty-first Level

To develop the area below the eighty-first level, two slope shafts, designated as "A" and "C," have been sunk in the vein. The incline distance to the ninety-sixth level in these shafts is 1,600 ft. below the eighty-first and connection has been made between them on the ninety-first level. In line with the bottom cross-cut from No. 3 Tamarack to the vein, a third slope shaft has been sunk below the eighty-seventh level. This slope is also connected with "C" shaft and is served by the eighty-first level haulage to Red Jacket shaft.

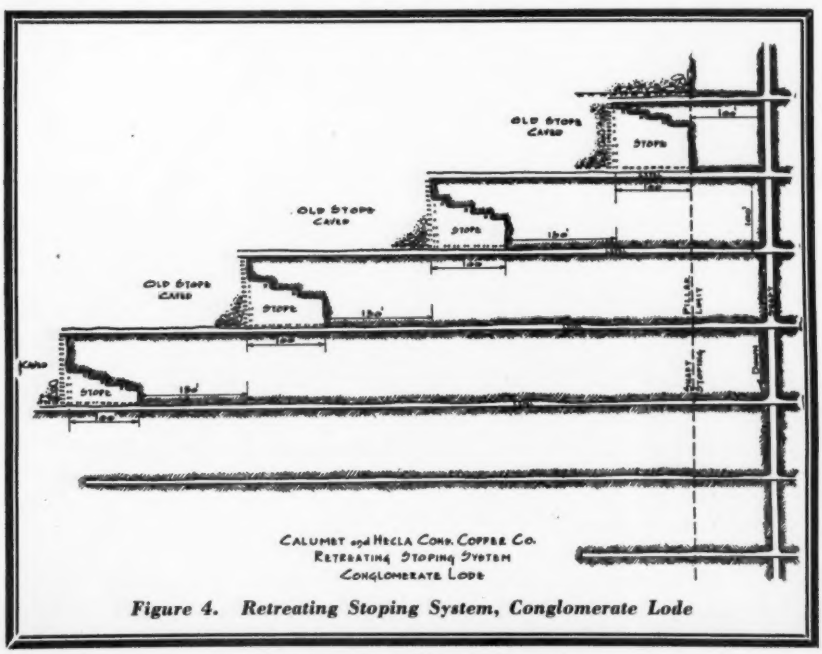


Figure 4. Retreating Stoping System, Conglomerate Lode

Shaft Pillars

The length of the pillars of vein left standing to protect the operating shafts has been increased continually as depth was attained. In some of the early work at very shallow depths the shaft pillars were 15 to 20 ft. in length on each side of the shafts. This was increased to 100 ft. and it is now planned to leave a 200-ft. pillar on each side of the shafts below the eighty-first.

Eighty-first Level Haulage Project

As mentioned, the eighty-first level project may be considered a reestablishment of important surface facilities at a point 8,100 ft. along the dip below the surface. In principle it is a scheme for concentrating at the eighty-first level all main haulage requirements for a mine below this level, locating on the eighty-first the collars of all shafts penetrating below it, and making possible the permanent use of existing vertical shafts for rock hoisting and other purposes, so that continual full capacity production may be maintained, at minimum cost, up to the time in the future when general "scramming" operations become necessary.

To meet these requirements a throughgoing tunnel paralleling the Conglomerate was deemed necessary to give direct access from Red Jacket shaft to the Hecla workings at the south end. To fulfill the expectation of safety, permanence and low upkeep, the selection of a location with reference to the Conglomerate workings was of vital importance.

Although failure of the hanging-wall rock ordinarily decreases more or less regularly with distance from the Conglomerate, movement of hanging en masse results when the formation is cut by a large number of prominent slips, among which the movement may be distributed, with the result that the live load is carried to considerable distances above the workings. The foot-wall was therefore considered to offer the only stable ground, and decision was made to drive the tunnel along an amygdaloidal bed which lies 200 ft. horizontally below the Conglomerate. This bed was found to consist of a soft amygdaloid of the

fragmental type, barren of mineralization, and to be of sufficient width (approximately 30 ft.) to encompass the entire cross-section of the tunnel (9 ft. by 12 ft.) and still leave sufficient vein material overhead so that breaking into the base trap of the overlying flow might be avoided and the probability of block caving thus averted. The distance below the Conglomerate to this bed is sufficiently great to permit absorption by the surrounding traps of the major pressure resulting from the closing-in of stoped-out areas above.

The length of the haulage-way, including the enlarged Red Jacket cross-cut, is 9,800 ft. from the Red Jacket shaft to the south extremity at No. 12 shaft. To facilitate handling timber, drill steel and other supplies and equipment from No. 12 incline shaft to the haulage-way and thence to the incline shafts below, all track gauges have been made the same, i. e., 4 ft. 4 in., and direct connections have been made between shafts and haulage by means of curved "drop-rails."

The "A" and "C" incline shafts are equipped with electric hoists located on the eighty-first level, capable of winding from a depth of 3,000 ft. below. Haulage equipment consists of motor-generator set with capacity for two 13-ton and one 10-ton trolley locomotives operating from 250-volt d. c. trolley-wire over 50-lb. rails. Tram cars are of 7½-ton capacity, and trains of 12 cars are loaded from pockets at the incline shaft heads, and dumped into pockets at the Red Jacket shaft by means of air-operated rotary dump-cradles, *Figure 2*. Locomotives and cars are connected by M. C. B. ¾ couplings with tripping device by which single cars may be rotated without breaking train. All trains operate under control of a complete electric block signal system; and to control the mine ventilation, all doors in the main haulage-way are mechanically opened and closed by trains in motion (*Figure 3*).

Figure 9. Timber crushing at base of stope

Development by Drifts

Development of the vein from the incline shafts consists in cutting plats or stations at each 100 ft. of incline depth, from which drifts (8 ft. by 9 ft. in size) are driven to the limit of the adjacent mining area, i. e., to the property limit or to a pre-established limit between shafts. The timing of drift advance is such that the upper drift of a group shall reach the mining limit before the top stope of a tier of retreating stopes has reached the shaft pillar. This permits the top stopers to move down and start a new stope at the mining limit without loss of time.

Retreating Stoping

A complete stoping operation on either side of a producing shaft is a series of four retreating stopes on four successive levels, the top stope leading the next below by approximately 150 ft. and so on down. This lead is considered a minimum distance over which the floor pillar should remain intact during the active life of the stope above. (*Figure 4.*)

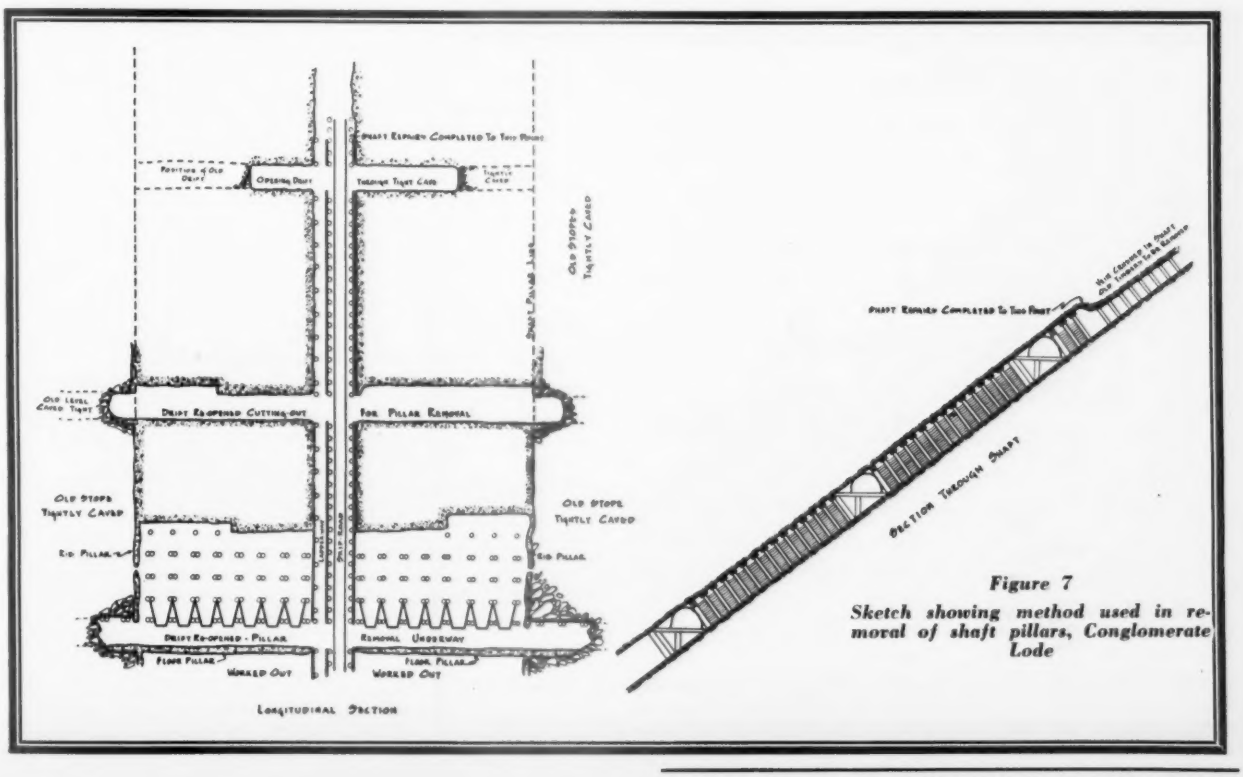


Figure 7

Sketch showing method used in removal of shaft pillars, Conglomerate Lode

No rock pillars are left standing in stopes. The length of an individual stope is now standardized at 100 ft., although in the earlier advancing system 200 ft. was the length for a long time. Floor arches were never recovered under the advancing system but thousands of linear feet have recently been profitably removed from between the old caved stopes. The operation is comparatively safe and is still being pursued.

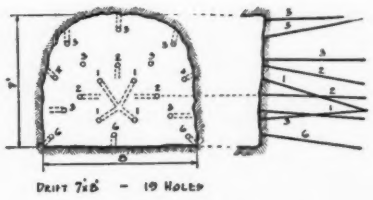


Figure 10

Stope Timbering

In the original mining operations stulls were used entirely for timbering stopes, later due to the vein increasing in thickness and quality, square set timbering was used in all stoping operations. This square setting was standard practice down to a depth of 5,500 ft. along the lode, but as greater depth was attained the commercial stoping thickness gradually diminished due to declining vein content and to save the excessive cost of the framed square sets, a gradual transition was made to the use of stull timbering which is now used entirely for temporary support in all stopes.

Timbering the lower portion of stopes has become largely a matter of standard practice, but the best judgment of operating foreman and head timberman is used in a determination as to the amount of and the spacing between stulls set in the upper portion of a stope. Standard practice at the present depth calls for four horizontal rows of stulls, in clusters of two timbers, 1½ ft. to 2 ft. in diameter, abutting each other, set with approximately a 7-ft. clear space between the near timbers and about 7-ft. centers between rows measured along the dip of the vein (*Figure 5*). These double batteries cover approximately 40 percent of the height of the entire stope and the practice of placing the double sets never varies up to that minimum height, regardless of how firm the hanging may appear during the early days of the stoping operation. Above this height (about 40 ft.) the stulls are placed singly with a variable increase in distance between centers, the actual spacing being governed by the appearance and action of the hanging in each particular case. Experience has shown that during the time required to complete a stope (approximately 100 days), the maximum thrust of the hanging wall manifests itself at a point about one-third the total height of the completed stope, or just below the fourth double timber set above the level. This is considered the critical support point in the entire operation, for while it is true the three double sets below must carry their particular load for a longer period of time, the actual thrust upon them is considerably reduced, due to the proximity of the unmined ground immediately below the level. Set No. 4 is below the center of the stope height and must hold the back for about 60 days after being placed, whereas the next timber row above is well toward the center of the stope height and is therefore above the point of maximum thrust of the vertically imposed hanging load; also the time during which the pressure acts upon it is considerably shorter. Each successive set from this point up is required for a shorter length of time and supports a hanging load which is gradually decreasing due to the support afforded by the caved-in material of the stope immediately above. Frequently the last 20 to 25 ft. require no timber, or at most a few odd stulls, placed as conditions require.

In drilling and breaking the vein at the stope face, two machines and sometimes three are operated simultaneously in each stope, the number depending upon the speed of extraction deemed necessary because of local pressure conditions. The operation may be classed an "under-slicing" or "bottom-slicing" plan, each slice taking about 6 ft. along the entire 100-ft. length of the stope. The first slice for a new stope, known as the "cutting-out," is started at the end of the proposed stope nearest the shaft and is extended toward the previously completed stope, which is usually well caved down by the time this first slice reaches it. Each successive slice thereafter is started from the side of the caved stope and extended toward the shaft, thus avoiding the necessity of the short raises which would be necessary if each slice were started from the shaft pillar side.

Figure 6 Stoping. It may be well to state here the manner in which the miner is protected from danger while starting the slice at the edge of the caved stope. *Just before each stope is completed*, to the level above, a double row of stulls known as the "breaker-row," is placed from bottom to top, within about 3 ft. of the shaft side or within 3 ft. of the ground next to be stoped. The row consists of pairs of heavy logs, abutting each other and each at least 2 ft. in diameter. These are set with a space of 3 ft. between pairs (measured along the dip), thus leaving a safe area 3 ft. in width, into which the hanging may not cave until the new stope has been sliced off. This row is not placed earlier during the progress of stoping, for the reason that approximately 3½ months is required to complete each stope, and the average life of the timber used, principally hemlock, maple and birch, is from four to six months. Therefore, from the time of completing one stope to that of completing the next, the major portion of the useful life of the "breaker-row" has been expended, which is the end to be desired. As the last slice at the top of each stope is cut the floor arch of the level above is drilled, preparatory to blasting, but the actual breaking is withheld until the slice has advanced sufficiently to leave a short length of the protecting arch above the driller. The stope above is by this time completely crushed in, but the danger of a sudden rush of caved material into the stope below has been obviated by a wall of heavy lagging timber, laid horizontally along the upper side of the "cutting-out" stull row at the time of completing the upper stope. This lagging is placed as the last timber operation is all stopes, anticipating the recovery of the floor arch from below.

Under the long-wall retreating system, adopted for the deep conglomerate workings, bursts have become quite a rare occurrence and are not looked for except in the last or next to the last stope at the shaft pillar. In removing the shaft pillar, although the adjacent stopes have by that time caved tightly, it may be said that almost every form of pressure result is encountered, such as wedging or the breaking of large masses from the pillars, heaving of the the foot, back subsidence and excessive drag. Pillar removal practice is indi-

DATA REGARDING PUMPS ON THE CONGLOMERATE LODE

Location of Pumps	Kind of Pump	No. of Pumps and Capacity in Gallons per Min.	Head Pumped Against	Total Gals. Pumped Year 1930	Average Flow G. P. M. over Entire Year
Tam. No. 5	Vert. Triplex Single Acting	1—250	1,000′	33,492,300	64
	Vert. Triplex Single Acting	3—334	2,424′	339,645,000	646
		3—334	2,732′		
Tam. No. 3	Hor. Duplex Double Acting	1—450	1,000′	205,983,900	392
	Vert. Triplex Single Acting	1—200			
	Hor. Duplex Double Acting	1—300	1,600′		
	Vert. Triplex Single Acting	1—200			
Tam. No. 1	Hor. Duplex Double Acting	1—300	900′	72,057,900	137
	Vert. Triplex Single Acting	1—150	300′		
R. J. S.	6 Stage Centrifugal	1—1000	642′	107,140,300	204
	5 Stage Centrifugal	1—600	300′		
No. 7 Hec.	Hor. Triplex Single Acting	1—400	740′	65,270,700	124
	Hor. Triplex Single Acting	1—400	740′		
		1—400	740′		
	Total.....			823,590,100	1,567

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cated by the drawing in *Figure 7*, *Figure 8* showing shaft timbering and hanging at edge of pillar-removing stope. *Figure 9* shows timber crushing at base of stope.

Drilling

Machine drills of the IR72, CP6 and Denver 7 type, mounted on 3-in. single jack posts are used entirely for stoping and drifting, and are operated under 80 lbs. air pressure. Jack-hammers are used only on special work, such as trimming in places and block-holing generally. Hollow hexagonal drill steel, 1 in. across flats, with ¼-in. holes is used throughout, a set consisting of 2-ft. starter and drills varying by 1-ft. lengths from 3 ft. to 10 ft., inclusive. Gauge of bits is reduced 1/16-in. for each increase of 1 ft. in drill length, starter bit is 1¾-in. 10-ft. finisher 1 5/16-in. gauge. Cross-bits are used entirely because of the tendency of single bits to jamb on account of the cracks encountered at the face in the deep conglomerate workings. The placing of holes in stoping slices is left largely to the miner, supervised by the shift-boss and varies considerably, due to the variable nature of the face caused by pressure slabbing or by jointing. In drifting, the pyramidal *drawcut* is standard practice, a cut requiring usually 18 to 20 holes, *6 ft. deep*, to give an advance of 4½ ft. per round. (See *Figure 10.*)

Blasting

All blasting is done at the end of the working shift. Powder is delivered to each miner once a week and stored in metal boxes provided with locks. Caps and fuse are kept in separate metal containers some distance from the powder. The powder sticks are 1⅛-in. in diameter, 8 in. long and consist of 30 percent nitroglycerin for old backs, 40 percent nitroglycerin for shaft pillars and stopes and 70 percent giant gelatin for drifts. In charging, the primer is set usually near the bottom of the charge and firing is done by fuse and detonators. Timing of firing is determined by the length of fuse cut for the particular hole. For special work, such as long raises and vertical shaft sinking, electric delay blasting is used with great satisfaction.

Tramming

The tendency of the conglomerate rock when blasted is to break into slab-shaped pieces so that in spite of the relatively flat vein dip, the greater portion of the material broken in stopes runs to the bottom. In shaft pillar removal timber chutes are built at the stope bottoms for car loading, but ordinarily for the retreating stopes rock is scraped from the drift floor up a scraper incline of sufficient height to permit the tram cars to be run underneath and filled by ore dropping through an opening in the scraper platform above. About 15 percent of the stope production coming from the upper stope faces is scraped down to the level by use of the same scraper as is used to fill the tram cars on the level.

To accomplish this, a "snubbing-post" and head pulley are set at the top of the stope and the scraper drag line after passing through a pulley on the hanging-wall side of the level is diverted to the head pulley. After cleaning out the stope it is a simple matter to replace the head pulley to an inside stull and resume scraping along the level.

All tramming equipment on development work and stoping consists of 3¾-ton end-dump tram cars, having a 4-ft. gauge. The haulage, except on the eighty-first, is accomplished by storage battery locomotives, 2 types being used: Type (1)—3-ton, single-motor, 48-cell, MV13 Exide Ironclad batteries. Type (2)—7-ton, single-motor, 48-cell, MV27 Exide Ironclad batteries. Each of these are single wheel drive through double reduction gears. The motor generator sets are of 2 types: Type (1)—40-kw., 125 volts, d. c., driven by 60 hp. motor. Type (2)—20-kw., 125 volts, d. c., driven by 31 hp. motor.

Ventilation

In spite of the great depth of the Conglomerate workings all primary ventilation heretofore has been taken care of through the medium of natural air currents. A relatively low average surface temperature combined with the high rock temperatures at depth produces a difference in air densities in different parts of the mine, resulting in a natural air flow, which is fairly uniform throughout the year because of the great length of the air columns and the comparatively small effect produced by changes in average surface air temperature. The mine openings are comparatively large and straight and the timber in shafts, drifts and cross-cuts is set in good alignment so that the amount of obstruction to the free flow of air is reduced to a minimum. Auxiliary ventilation of development headings and dead ends is cared for by electrically driven

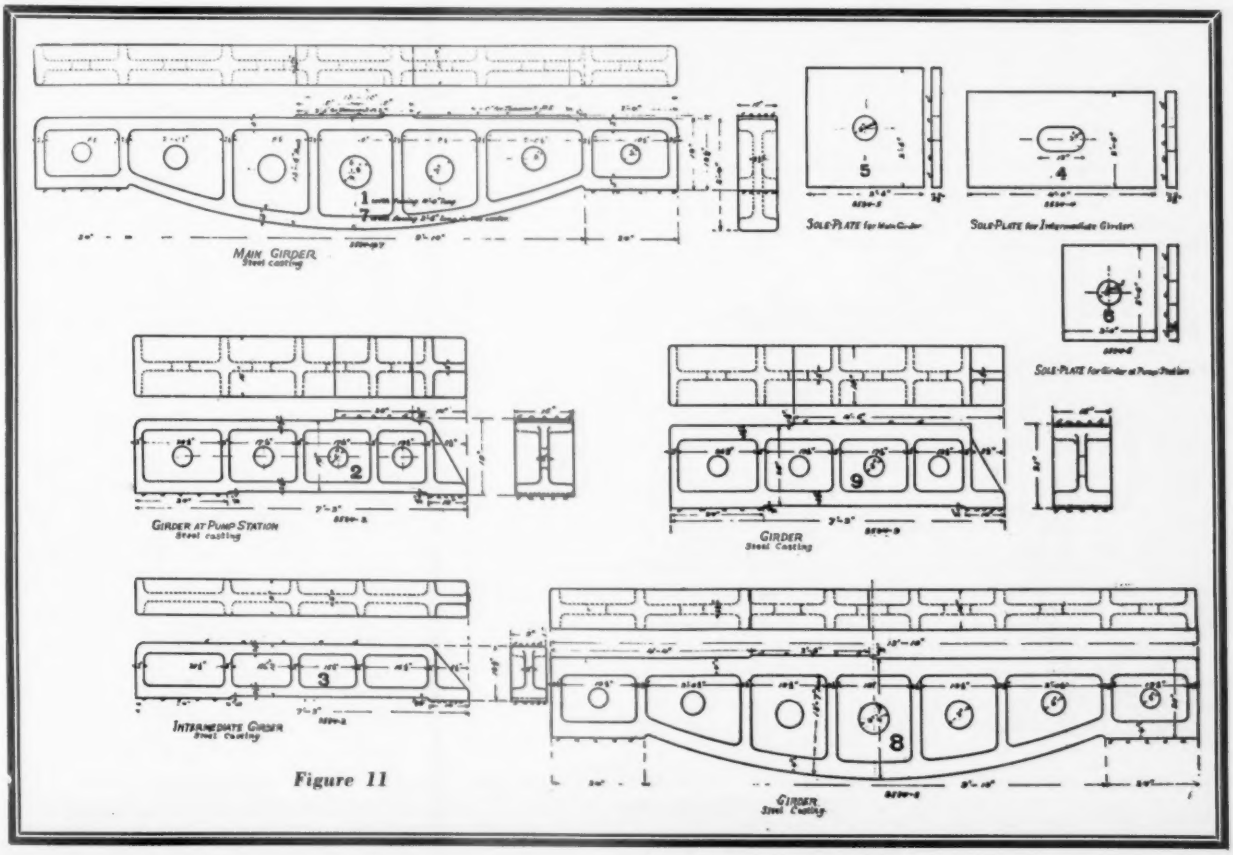


Figure 11

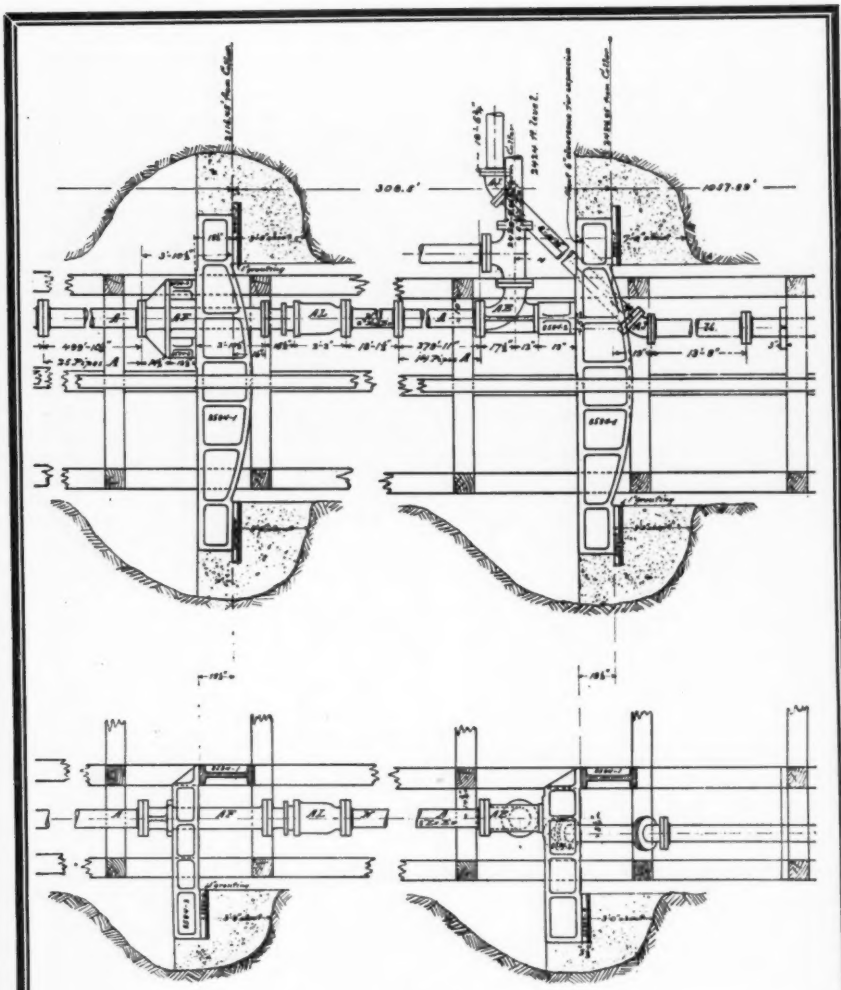


Figure 12

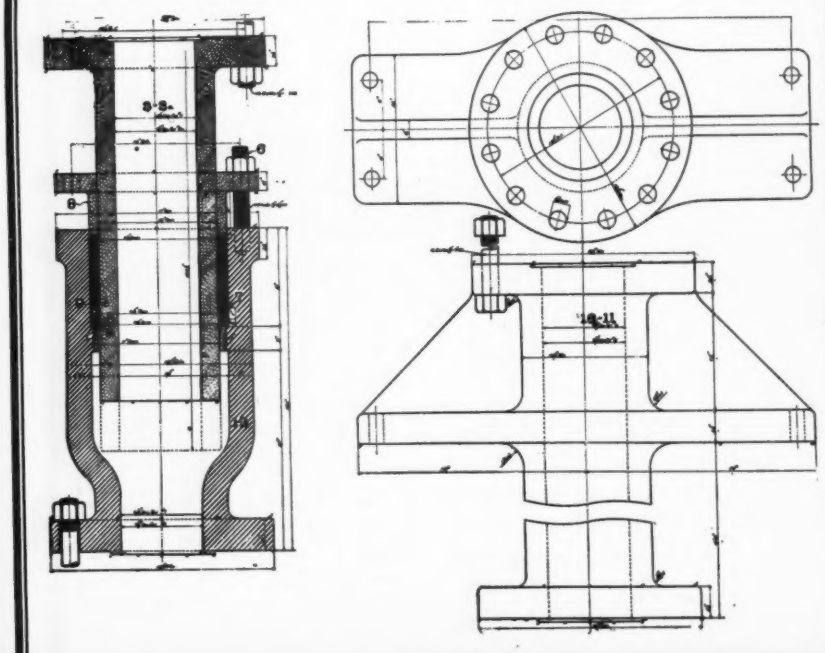


Figure 13

compressed air blowers. Local sources of heat, such as developed by motors in main pump and hoist rooms, are ventilated by large volume fan-pipe installations. Working conditions in the mine are very comfortable as a whole and the air is of excellent quality throughout although somewhat warm in the deep dead-end development openings.

Pumping

Glacial-drift running from 10 to 40 ft. in depth, covers the Calumet area and, while it is not possible to thoroughly drain this deposit over the entire area above the mine workings, a considerable saving in mine pumping has been accomplished by the use of surface intercepting ditches and surface pumps. So-called "collar" pumps are placed at points nearest under the shaft collars where sufficient water can be caught to justify a separate pumping unit. Somewhat more than 2,250,000 gallons per day are pumped to surface by the combined pumping facilities of the Conglomerate lode, the principal installation of which is located at No. 5 Tamarack vertical shaft.

This plant consists of 2 pump stations, one 2,424 ft. vertically below the surface, the other 5,156 ft. down, or 2,732 ft. below the upper station to which it delivers water in one lift. At each station, the equipment consists of the following:

Three 334 g. p. m. vertical triplex plunger pumps.

Three 350 hp. motors, using 440-volt a. c. current, starting on by-pass accomplished by ½ voltage or 220 volts taken from transformers.

One air compressor, triple expansion, delivering air to air chambers at 1,250 lbs.

Three oil transformers, 500 k. v. a., 4,000 volts to 440 volts.

One switch-board.

One fan, single inlet, rotor, 3-ft. diameter by 1.5 ft. wide, 30,000 cu. ft. capacity, driven by 75 hp. motor.

Water is supplied to the lower pumps from a large volume storage sump and relayed to a sump of nominal capacity just off the 2,424 pump room. The shaft water column consists of 8-in. diameter steel pipe, heavily galvanized inside and out. Flange connections are used, having male and female joints. During construction all pipes were threaded, flanges screwed on and base of flange welded to pipe, after which the welding strip was galvanized. Thus no threads or bare steel were left exposed to the corrosive action of the mine water. All pipes except short "filling-in" lengths are 20 ft. long and the columns are supported in the shaft by heavy cast-steel girders, at intervals of about 500 ft. The girders rest on concrete piers, carried in hitches cut into shaft walls. Immediately below each girder, expansion joints have been provided for the pipe line, to care for changes in pipe length which might occur during periods of interruption to the pumping service. The pipe and flanges used vary in weight from standard to double extra heavy, according to the position occupied in the column. See *Figures 11, 12* and *13* for details of supports and joints.

Conclusion

The brief discussion of operating conditions on the Conglomerate Lode as given above will, it is hoped, give a fairly general (*Continued on page* 508)

Underground POWER DISTRIBUTION *and* HAULAGE

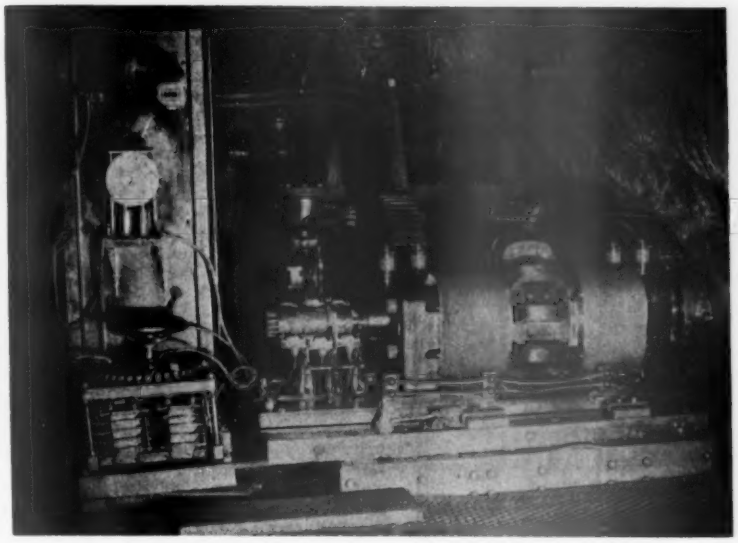


Figure 1. 1,250-volt D. C. Brush Arc Motor and Mine Pump installed in 1892 at 16th level, No. 11 shaft, South Hecla Mine

By

Carl L. Fichtel*

IN THE fall of 1892 the Calumet and Hecla made its first underground electrical installation consisting of two horizontal, reciprocating mine pumps located in No. 11 shaft of the South Hecla branch at the eighth and sixteenth levels. These pumps were driven through double-reduction gearing by 80-hp., 1,250-volt, direct current, series wound, Brush arc motors. (See *Figure 1.*) The motors were operated at 1,000 volts and current was furnished by a single shunt-wound generator for each motor, the circuits going underground through vertical drill holes located on the hanging side of the lode. The wires were fastened to a steel cable by means of wooden spools and were wrapped with marlin. The vertical distance to the eighth level is approximately 560 ft. and to the sixteenth level 1,080 ft. In the following year an additional pump was installed at the twenty-fourth level and the circuit feeding this unit was run down the ladderway in iron pipe.

These pumps operated for 10 years and were replaced in 1902 by a series of motor-driven pumps installed in No. 7 shaft Hecla at the twelfth, twenty-fourth, thirty-sixth and forty-eighth levels. Power for the operation of this line of pumps was furnished by a 300-kw., 25-cycle, 2,300-volt, 3-phase generator connected by a rope drive to a compound engine. The circuit for the transmission of this power consisted of three single-conductor, 4/0 gauge, rubber-insulated wires installed in a 4-in. iron pipe. The wires were held by means of wooden clamps made in two pieces and bolted together. The method used in those early installations was good in principle and has been followed, with slight modification, for all later installations through the inclined shafts.

* Assistant Electrical Engineer.

Power for Pumping and Lower Conglomerate Workings

The single-line diagram (*Figure 2*) shows the circuit layout for the No. 5 Tamarack pumping shaft through which power is furnished for the eighty-first level development (consisting of hoisting, haulage, auxiliary pumping, etc.), and for No. 3 Tamarack and tributary workings as well.

Power is delivered at 13,200 volts from the main generating station to an outdoor transformer substation consisting of two banks of 3,000-k. v. a., 13,200/2,300-volt, oil-filled self-cooled transformers, delta connected on the high tension side and grounded "Y" on the low voltage side. The station layout is in duplicate; a double 4,000-volt bus is provided and either bank of transformers can be put on either bus. Each feeder is equipped with double-throw, disconnecting switches so that each feeder can be connected to either bus. The system is not intended for parallel operation, and disconnecting switches are provided in the lines at various stations in the shaft for sectionalizing. Either feeder can carry the entire load, but under normal operations one feeder carries the main pumping load and the other the hoists, haulage and extra apparatus. In designing this feeder layout the following factors had to be considered:

(1) Safety to life. (2) Freedom from fire hazard. (3) Reliability. (4) Accessibility; so that in case of trouble, repairs could be made. (5) Transmitting the required amount of power with a potential and wire-size consistent with the physical conditions of the shaft and the space available for installation.

The first feeder was installed in a pipe compartment (size 3 ft. by 7 ft. 2 in.), which also contained an 8-in. water column, a 10-in. air main and clearance for the "Dummy" hoist used during installation. Anchor boxes were lag-screwed to the dividing timbers and were spaced about 40 ft. apart, varying according to the timber sets. Each anchor box held the section of pipe below it and the wire in that section. In order to withstand the corrosive action of the water in the shaft, cast-iron pipe was used; it was 5 in. in diameter, flanged at both ends, and furnished in 12-ft. lengths.

Each section consisted of the anchor box and three full lengths of pipe, a matching piece, if necessary, and a slip-joint bolted to the top of the next box. (See *Figure 3.*) Each slip-joint consisted of a piece of 6-in. pipe flanged and bolted to the 5-in. pipe, and a piece of 5-in. turned to an easy fit inside the 6-in. pipe and bolted to the top of the anchor box. The object of the joint was two-fold: *First*, to provide for expansion and to give a certain amount of flexibility to the line, and *second*, to facilitate connecting the sections. The joints when closed were about 2 ft. long.

The wire used was single-conductor, 8/32-in. rubber-insulated, with heavy weatherproof braid over the rubber, then a .020 by ¾-in. flat copper tape wound spirally, and over all a heavy jute, weatherproof braid. It was furnished in 543-ft. lengths, each length on a separate reel. In making the installation the three wires were fastened to the "Dummy" hoisting rope and drawn up the shaft; the lower ends were then fastened to a hemp rope that had previously been threaded through the pipe. The wire was fed through the face of the anchor box and lowered through the

pipe section. A strain was kept on the hemp rope to avoid any possibility of jamming in the pipe. After the wire was lowered into place, the upper end was transferred from the hoisting rope to a chain block; and as each clamp was fastened to the wires, starting from the bottom, a small amount of slack was given to secure the proper seating of each clamp as well as to put a slight bend in the wire to allow for expansion.

The holding clamps were made of asbestos-wood in three pieces and were held together by steel castings with four studs. Before the holes through each clamp were drilled, 1/16-in, fillers were placed between the pieces and the holes were drilled to fit the exact outside diameter of the wire. The filling strips were then removed and as the clamp was applied to the wire, the sections were drawn tightly together with the proper amount of compression to hold the wire. The holes were laid out in an equilateral triangle and came within the inside diameter of the pipe so that there was no side strain against the wire. The details and dimensions are shown in *Figure 3*.

In case of a short circuit or ground, possibility of the insulation burning for any considerable distance through the pipe was avoided by a complete fire-damper in each anchor box. This consisted of soft asbestos gaskets placed tightly around the wires; upon them and underneath the holding clamp was an ebony, asbestos-wood sealing-block cut to fit the wire and completely covering the bottom opening in the box. The cover was provided with a half-round rubber gasket and securely bolted to the box. Brass bolts and nuts were used for this purpose so that corrosion would not affect their easy removal. Gaskets were placed between all flanges so that the whole line was water-tight. All wire joints were made with mechanical, solderless connectors and covered with rubber tape. It may be of interest to state that in order to prevent entrapping moisture in the joints, it was necessary to build pentices at several points in the shaft to keep the water away while the joints were taped. After each joint was made the metallic sheaths were connected across the joint and the three sheaths were bound together and grounded to the brass bolt provided in the side of the anchor box for that purpose. All slip-joints in this conduit line were bridged by copper wire, and the conduit line was grounded to the air mains and water column every 500 ft.; at the shaft entrance these pipes were grounded to the main transformer ground.

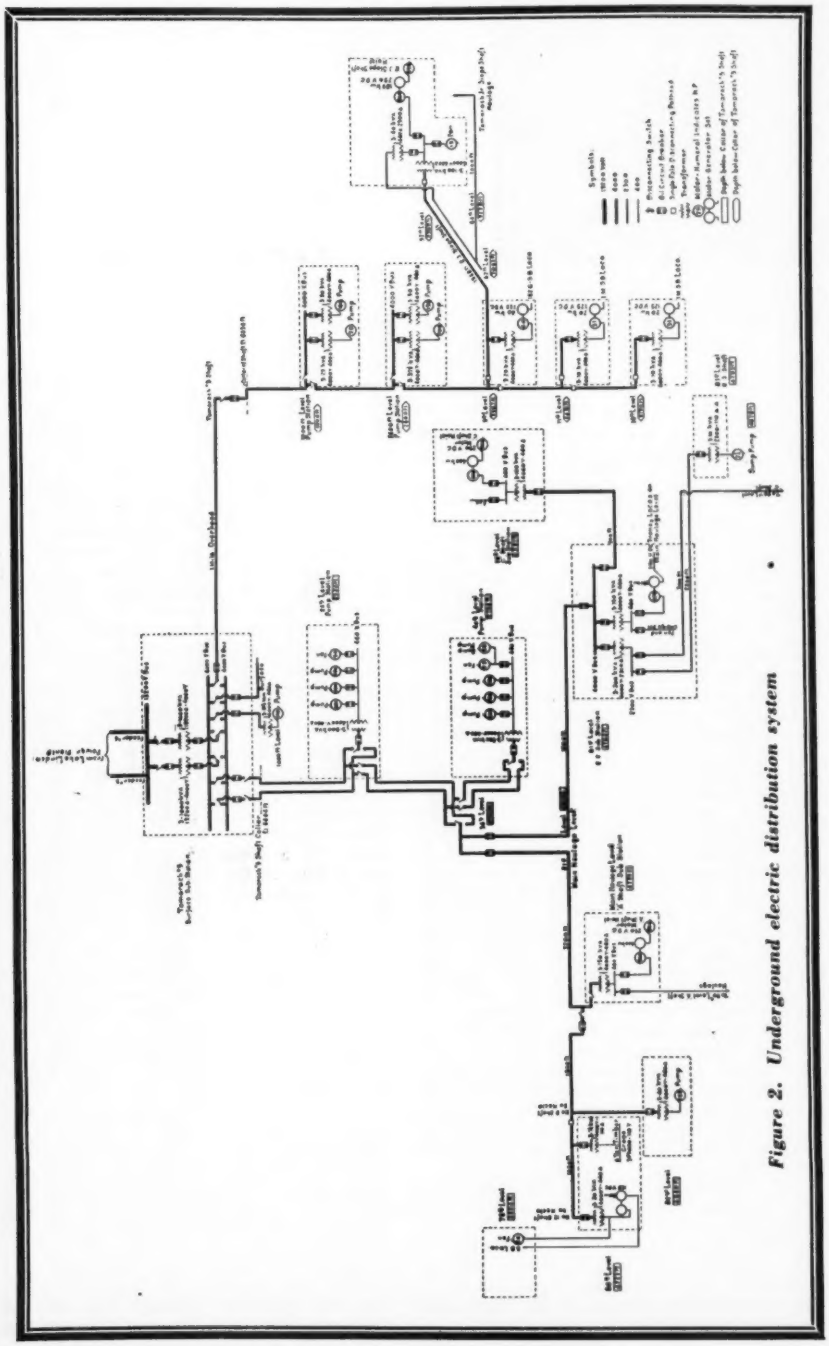


Figure 2. Underground electric distribution system

Six hundred thousand cubic millimeter wire was installed from the substation to the first pumping station, 2,424 ft. below the shaft collar. From that point to the bottom pumping station, a distance of 2,732 ft., 500,000 c. m. wire was installed, with a take-off at the thirty-sixth level. The second circuit was installed in a similar manner but was located in the corner of one of the shaft compartments. The only change made in this installation was that the wire had a braided copper covering instead of the flat copper tape and was without the weatherproof tape. At the thirty-sixth level, which connects with the eighty-first level haulage drift by means of a short crosscut, there is located the take-off station (*Figure 4*) from which two feeders extend. One of these circuits is 300,000 c. m. wire; it extends north through the haulage level to the railway substation and on to the seventy-eighth level of "C" shaft where the substation for the hoist is located. The other circuit extends south to the substation at "A" shaft; it is 4/0 gauge.

Installed in this shaft also is a 3-conductor, 4/0, varnished cambric cable that provides power for a pump at the 1,000-ft. level. This cable is suspended from the top of the shaft and is held by a cable bell.

No. 3 Tamarack shaft, situated about one mile north of No. 5 shaft, is also fed from the same substation by an overhead line and is equipped with a single circuit to the bottom or eighteenth level, a vertical distance of 5,191 ft. Similar construction is used throughout with the exception that, instead of making solid joints in the wires, single disconnecting potheads are used. The electric feeders in these two shafts provide the power for the lower conglomerate workings and extend about six miles.

In addition to No. 5 and No. 3 shafts, there are two other vertical shafts equipped with electric feeders. Red Jacket Shaft has a 440-volt circuit of 500,000 c. m. wire extending down a depth of about 600 ft. to a 335-hp. centrifugal pump; and from that point down about 340 ft., a 4/0 circuit is run for a

LENGTH OF CIRCUITS AND EQUIPMENT INSTALLED

Branch	Shaft No.	Depth of Circuit	S. B. Locomotives 1M	MS-4	132-G	M. G. Sets* 20 Kw.	40 Kw.	Fans No.	H.P.	Scraper Hoists No.	H.P.	Pumps Total No.	H.P.	Transformers 2300v./460v. No.	KVA.
Amygdaloid	13	3,658	4	..	..	3	..	..	..	..	..	1	20	9	90
	14	3,758	3	..	..	2	..	..	..	1	25	..	..	9	90
	15	4,164	3	..	..	2	..	..	..	2	50	2	55	12	120
	17	2,134	3	..	..	3	..	..	..	..	..	..	..	9	90
Lower Conglomerate	"A"	974	8	..	..	4	..	..	..	..	..	..	..	..	..
	"C"	1,240	2	..	1	1	1	..	..	..	..	1	75	6	180
	9	125	..	..	..	..	..	..	..	..	..	1	125	3	120
	12	200	1	..	..	1	..	1	30	..	..	..	..	3	60
	R. J. Sub.	1,548	4	..	1	3	1	1	15	..	..	..	..	12	165
	Tam. Jr. Sub.	300	3	..	..	1	1	..	..	..	..	..	..	3	30
Ahmeek	3	5,591	5	5	..	6	..	1	25	1	25	1	25	30	300
	4	3,384	7	..	..	4	..	..	..	..	..	3	425	18	600
	2	4,643	..	..	..	..	..	..	..	..	..	5	800	6	999
	2	5,546	7	3	5	5	4	1	75	..	..	3	225	39	825
Kearsarge	1	4,942	..	..	..	..	..	..	..	..	..	5	610	12	930
	4	1,869	3	..	..	2	..	..	..	1	25	1	25	9	90
So. Hecla	7	3,400	..	..	..	..	..	..	..	..	..	3	330	9	337½
Centennial	2	4,500	..	2	..	..	1	..	..	..	..	1	20	3	60
Osceola	3	530	..	..	..	..	..	..	..	..	..	2	70	3	75
	6	4,368	..	..	..	..	..	..	..	..	..	1	75	6	150
Totals		56,874	53	10	7	37	8	4	145	5	125	30	2,880	201	5,311½

* Note: 31 H.P. motors on 20 Kw. sets.
60 H.P. motors on 40 Kw. sets.

SUMMARY OF UNDERGROUND ELECTRICAL EQUIPMENT

Total length of shaft feeders, approximately	17 miles
Total K. V. A. transformers	11,051
Total number of transformers	237
Total horsepower—A. C. motors	9,790
Total number of A. C. motors	116
Total number of D. C. motors	81
Total number of D. C. generators	52
Total number of type 1M locomotives	53
Total number of type MS-4 locomotives	10
Total number of type 132-G locomotives	8
Total number of 13-ton trolley locomotives, 250 v.	1
Total number of 10-ton trolley locomotives, 250 v.	1

100-hp. centrifugal pump. No. 1 Tamarack shaft is equipped with a 2,300-volt circuit consisting of three 4/0 rubber-covered wires suspended from the top by strain insulators and extending down the shaft through a 4-in. pipe for a distance of about 900 ft. to a pumping station.

Distribution Through Inclined Shafts

In addition to the shafts mentioned above and the equipment as shown in the single-line diagram, *Figure 2*, the company has 13 other shafts wired for power service. These circuits are all 2,300-volt, 3-phase, 25-cycles and consist of three single rubber-insulated wires installed in iron conduits. The wire is held by asbestos-wood blocks placed in anchor boxes that are spaced from 200 to 300 ft. apart, depending on the size of the wire. The smallest wire installed is No. 2 B & S gauge and the largest circuit, at No. 2 shaft, Ahmeek, is 500,000 c. m.

The accompanying tabulation shows the length of circuits down the shafts and the equipment installed.

Mine Haulage by Electric Locomotives

Storage battery locomotives are used exclusively in the Calumet and Hecla Consolidated Copper Company's mines with the exception of the main line haulage on the eighty-first level. (See Mr. Vivian's description of operations on Conglomerate Lode.) There are 73 of these locomotives in service at the present time: 55 type 1M, 10 types MS-4 and 8 type 132-G. All of them have inside frames and are equipped with steel wires.

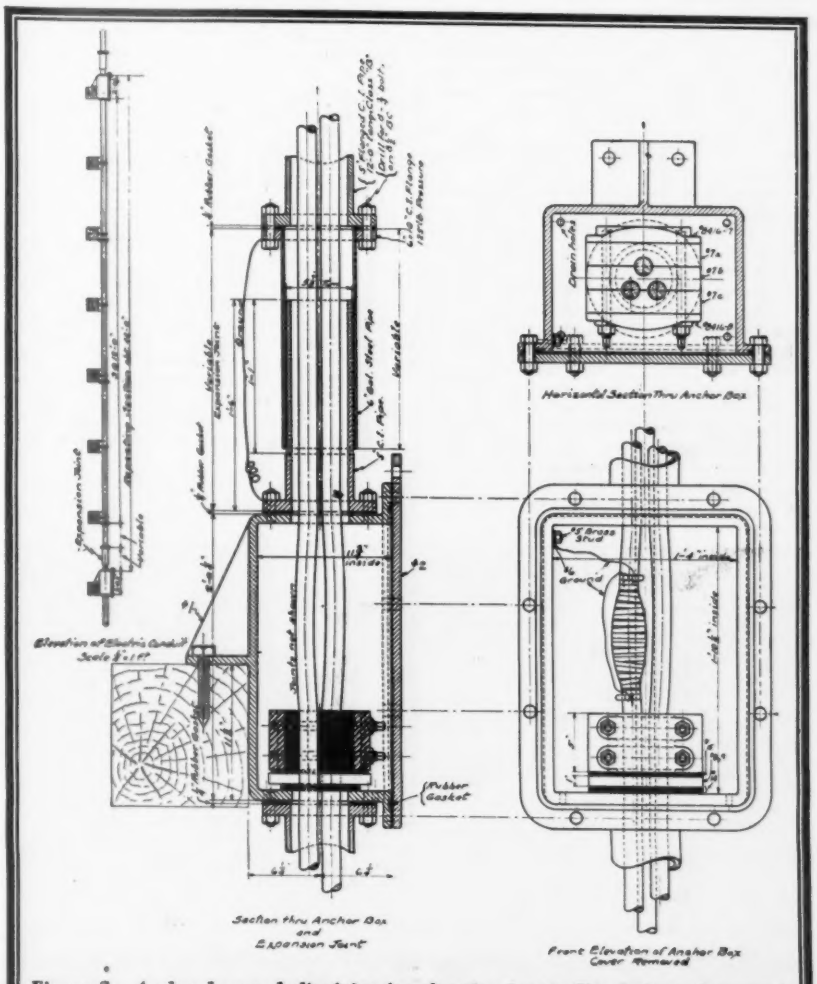

Section thru Anchor Box and Expansion Joint
Horizontal Section thru Anchor Box
Front Elevation of Anchor Box Cover Removed
Rubber Gasket

Figure 3. Anchor box and slip joint for electric wires in No. 5 shaft, Tamarack

Figure 4. Take off station at 36th level, No. 5 Tamarack

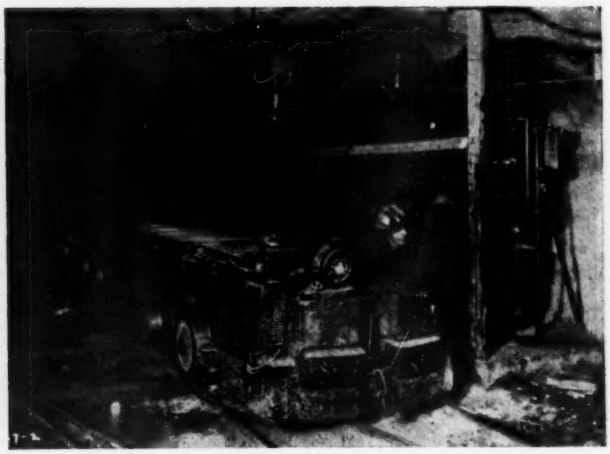


Figure 5. Type 1M Storage Battery Locomotive and Battery Charging Station

The type 1M is a 3-ton chassis equipped with 48 cells of MV-13 Exide Ironclad batteries. It has a single motor and two-wheel drive, the motor being geared to one axle through an intermediate gear and pinion. The weight on the driving wheels is so proportioned that they will slip before any excessive strain comes on the electrical equipment. The total weight of the locomotive is 8,352 lbs.; it has a starting drawbar pull of 1,300 lbs., a running drawbar pull of 1,000 lbs. and a speed at rated drawbar pull and voltage of 3½ miles per hour. (See *Figure 5*, locomotive and charging station.)

The MS-4 locomotives were originally 4-ton, 125-volt, single motor, 4-wheel drive, trolley type but were converted to battery type. They are equipped with 54 cells of MV-15 batteries and weigh approximately 13,000 lbs. total.

The 132-G locomotives are similar in construction to the type 1M but are larger, weighing with 48 cells of MV-27 batteries approximately 16,000 lbs. These locomotives are the 2-wheel drive type. The motor pinion meshes directly with the gear on the driving axle. The weight on the drivers is so proportioned as to develop a starting drawbar pull of 3,160 lbs. and a running pull of 2,375 lbs. with a speed of 4 miles per hour.

The veins of the Calumet and Hecla mines are relatively narrow, averaging from 12 to 15 ft. The system of mining is such that the tonnage available each day from any one level is limited. It seldom exceeds 250 to 300 tons and is often less. The drifts are extended with a grade of about 1 inch in 10 ft. in favor of the loads and are fairly straight. Thirty-five-pound rails are used. There are two track gauges, 48 in. in the main working and 40 in. in the Ahmeek, Kearsarge and Centennial branches.

Haulage Distance and Load

Skips used at these properties are of two sizes, namely, 5 and 8 tons; and tram cars are of three sizes, namely, 3¾, 5 and 8 tons; and trains are made up in multiples of the skip capacity. The larger locomotives are used for handling the 5 and 8-ton cars. Two or four of these cars make up a train; the average distance hauled is about 1,000 ft. and the maximum about 5,000 ft. The type 1M locomotive handles the 3¾-ton and, in some cases, the 5-ton cars, a train consisting of two or four of the 3¾-ton cars or one or two of the 5-ton cars.

At the Red Jacket sub-shaft 2½-ton cars are hoisted up the incline shaft, which dips 22 degrees below the horizontal, by an electric hoist to the fifty-seventh level where they are made up into trains consisting of six cars and hauled to the Red Jacket shaft by one of the 132-G type locomotives. The distance is about 2,700 ft. and a tonnage of about 375 tons per day is hauled.

Charging and Maintenance

Motor generator sets of 20-kw. capacity are used for charging the batteries on the type 1M and MS-4 locomotives, while 40-kw. capacity sets are used with the 132-G type. Each set consists of a 440-volt, 25-cycle, 3-phase, 1,500 r. p. m., squirrel cage, induction motor mounted on a common bed plate and direct connected by solid couplings to a 125-volt, flat compound wound, direct current generator. (See *Figure 6*). A modified constant potential charging system is used and a fixed field resistance in place of the regular field rheostat, so as to put voltage regulation out of the control of the men charging the batteries.

The locomotives are taken by the trammers shortly after 7 a. m., and are in operation until about 3.30 p. m., when haulage operations are stopped until about 8 p. m., the beginning of the night shift. From 3.30 p. m. to 8 p. m. the locomotives are in charge of inspectors whose duty it is to put the batteries on charge and to do the necessary upkeep work. At 8 p. m. the locomotives again go into service and operate until about 4.30 a. m., the end of the night shift. At this time they are again placed on charge until the beginning of the next shift. The original plan consisted of a motor-generator for each locomotive, but it was found that one set could take care of two batteries without any difficulty, and now in most cases two batteries are charged simultaneously from the one set. Care must be taken that batteries of the same number of cells are charged from the same set and that a certain time elapses before the second battery is placed on charge so as to prevent the high initial charging peaks from overlapping. The locomotives are usually located on adjacent levels that are about 125 ft. apart and the 125-volt circuit is run down or up, as the case may be, to a small switchboard panel on which are mounted overload and reverse-current cir- (*Continued on page* 508)

Figure 6. Battery charging station

Underground
SAFETY WORK

By J. W. Alt*

COMPARATIVE STATEMENT OF PERSONAL INJURY ACCIDENTS PER MONTH OF.....1931, AND THE YEAR 1931 TO DATE

Shaft	Shift Boss	Period	Total Shifts	Total Accds.	No. per 1000 Shifts
Department				Captain	
#		Captain Month To Date Month To Date Month To Date			
#		Captain Month To Date Month To Date Month To Date			
#		Captain Month To Date Month To Date Month To Date			
Total	This Month This Year Inc. This Mo. Same Month Last Year Last Year Inc. Same Mo.				

THE safety department undertakes to see that all underground work is carried on in a safe way, that each employe is properly educated as to the hazards, dangers and safety rules pertaining to his particular job in addition to the general underground rules, and that regular, periodic inspections are made to ascertain whether the foremen are carrying out and enforcing the safety rules and regulations of the department. To accomplish the educational and inspection work, the company has a sufficient number of safety engineers who are assigned to various branches, with the idea in mind that the territory to be covered by any one man shall not be too large to allow him ample time to visit and thoroughly inspect every working place at least once a week. The safety engineers are technical men who have had underground experience and who understand mining conditions.

The safety department has its headquarters in the central claim and employment building where it has ready access to all accident records. Being thus centralized, there is opportunity for the members of the department to meet frequently to discuss safety conditions and exchange ideas on safe and unsafe practices. Safety rules and safe practice codes or booklets are published from time to time and given to the employes doing the particular work referred to in each issue. The safety rules and safe practices recommended are strictly enforced and violators of the rules are disciplined.

The foreman is recognized as the key man in preventing accidents and everything possible is done to help him improve his accident record. The safety engineer makes it his duty to be with each foreman a whole day at least twice a month. In this way he is able to observe and help the foremen and they are encouraged to call on him for assistance in solving their particular safety problems. When the safety engineer notices any unsafe practice, poor guarding or lack of guarding, it is called to the foreman's attention immediately. It is felt that this plan establishes a better spirit of cooperation between the safety and the operating departments than if a formal written report were to be made later. Another reason for frequent contact with the foremen is the desire to help them to become "safety-minded" and to more readily recognize unsafe practices. Each month the foremen are furnished individual reports showing the accidents they have had for the month, the date of their last accident, the number of accidents for the year, the number of accidents for a corresponding period during the preceding year and each one's best record in number of shifts without a lost-time accident. These records put the foremen in competition with each other and keep them stimulated to strive for a better showing.

Pertaining directly to safety, there are four major branches of underground operations: the Calumet Conglomerate, the Osceola-Centennial, the Ahmeek-Kearsarge and the Isle Royale. Meetings with the captains and foremen are held at least once a month at each of the branches, or, if necessary, more frequently. At these meetings the previous month's accidents in the branch and any

* Safety engineer.

(Form of Report to Foremen)

YOUR ACCIDENT RECORD TO JUNE 1, 1931 C & H CONGLOMERATE

Foreman	May Acc'ds.	Shifts for May	Last Acc'd.	No. shifts from last Acc'd.	TOTAL YEAR TO DATE 1930 Acc'd. Freq.	1931 Acc'd. Freq.	Best record in shifts

unusual accidents in the other branches are discussed, safe practices are reviewed and, before any new safe practice codes are published for general distribution, they are presented for consideration to the members who attend this meeting. Thus the foremen have an opportunity to suggest alterations or additions.

Large curves or graphs are made of each foreman's accident frequency record and also large curves of each branch for frequency and severity, and these graphs are displayed at the different meetings to give the captains and foremen a clear picture of just what is being accomplished in accident prevention. To each superintendent and captain of the different branches are given copies of the monthly accident report for his branch and also a monthly frequency report giving his standing for the month, for the year to date and for a corresponding period of the previous year. This report form is shown.

At irregular intervals during the winter months the captains and foremen of the various branches have a get-together meeting at which dinner is served. Following the dinner there is a short program of talks. These meetings are held in some hall or club where the evening can be spent in having a general good time. Once a month a company safety-news-letter is published and sent to all captains, foremen and others in charge of various departments, the purpose being to stimulate interest in the safety movement, to create competition for the best safety record among the different branches and to furnish information that will help to prevent accidents. At each dry or change-house is displayed a large calendar made up to suit each branch. This calendar is kept up daily and shows the previous month's accidents, the accidents for the year to date and the accidents for the current month. It arouses a great deal of interest among the employes and helps to create a friendly spirit of competition between the various shafts.

The central claim and employment department keeps detailed and accurate records of all "lost time" and "no lost time" accidents; in other words, records of all men who report to the company's doctors on account of any injuries received while on or off duty. These records are available to the safety department and are made use of in the study of accidents. When accident "repeaters" are found, each case is taken up individually and usually the employe is talked to while he is on his job where facts can be presented by the safety engineer in a concrete way, pointing out to him just how he could have avoided being injured. By following this procedure, it has been observed that the most careless employes have tried to become more careful workers. The safety department endeavors to build up a friendly attitude between its members and the mine employes so that they will freely give their ideas and opinions regarding safe practices.

Hiring New Men

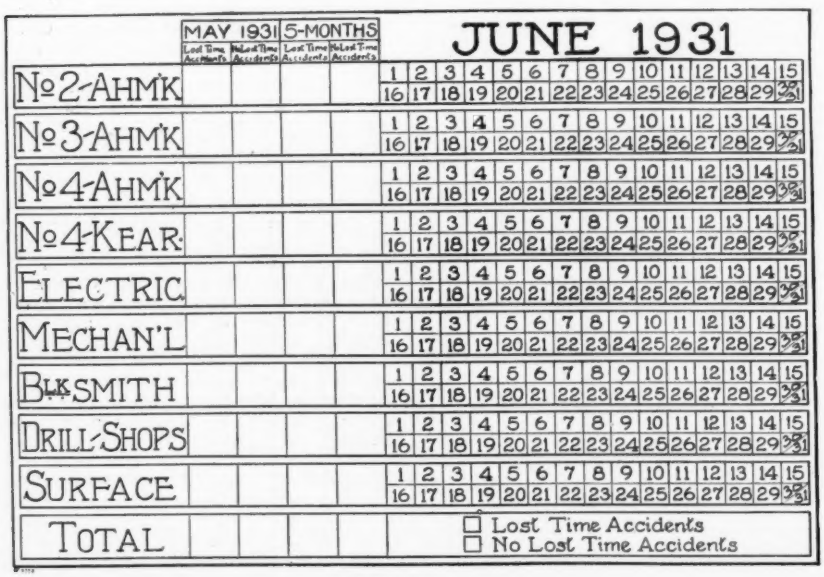
When a new man is hired to work underground, he is told about the safety equipment he must have before going to work and is given a short talk by the captain as to the company's safety policy. The safety department is kept informed regarding the men hired and it is the duty of the safety engineer to see that each new employe thoroughly understands the safety regulations of his job as well as the safety policy of the company.

First Aid and Mine Rescue

The company maintains a well equipped, centrally located station where employes from the different branches receive training in first aid and mine rescue in accordance with the standards recommended by the United States Bureau of Mines. This work is in charge of a competent man who devotes his entire time to the training of employes and the maintenance of equipment. During the past year, under the direction of the United States Bureau of Mines, all of the employes of the company were trained in first aid and were given first aid certificates by the Bureau; and in addition, the various branches, shafts and departments were awarded certificates showing that all of the employes had received this training.

Cleanliness

Cleanliness is emphasized as an important factor underground. The levels are kept clean and even with the ties of the track and no piles of dirt are allowed to accumulate. Small open boxes for waste carbide and rubbish are placed at convenient points throughout the mines and are emptied at regular intervals. Sawdust and paper from powder boxes, empty powder boxes, old timber and old, oily waste are not left lying around but are removed immediately, for it is a recognized fact that clean, tidy surroundings are conducive to safety habits and "safety-mindedness."



Accident Calendar

CALUMET AND HECLA CONSOLIDATED COPPER COMPANY

MINING METHODS ON CALUMET CONGLOMERATE

(*From page 502*)

idea as to the problems met with. The deep mine rock pressure conditions are comparable with those of the Ooregum mine of the Kolar Gold Field of South India, the Witwatersrand gold mines of South Africa and the St. John Del Rey mine of Brazil, all of which have somewhat deeper workings than those of Calumet.

A great deal of literature and discussion has been published showing the remarkable ingenuity and skill with which the engineers and operators of those fields have successfully met and overcome numerous difficulties of the most adverse character and, in the face of this testimony, it is the confident belief of those operating the Conglomerate vein that much greater depths may be attained before the physical obstacles encountered will have increased sufficiently to threaten the success of the operation.

POWER DISTRIBUTION AND HAULAGE

(*From page 506*)

cuit breakers. Each charging station consists of three transformers, switchboard and motor starter in addition to the motor-generator set. The wiring connections to the transformers, cut-outs and motor starters are mounted on a pipe frame-work, and the complete assembly can be readily moved to a new location when the locomotives are transferred to other levels. The average life of the batteries is about 30½ months and the work demanded of a battery averages about 1¾ cycles per day.

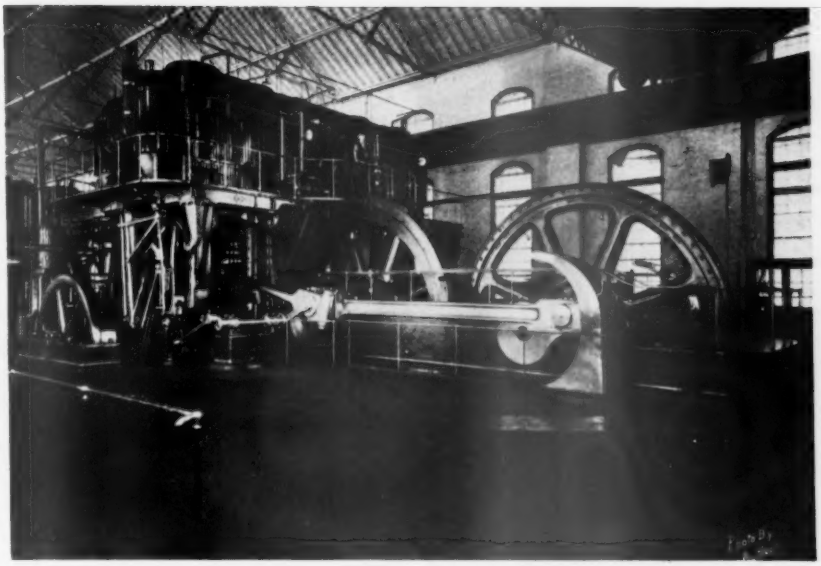


Figure 1. Minong & Siscowit hoist, Red Jacket shaft

HOISTING
Equipment and Methods

By
Thos. P. Soddy*
and
Allan Cameron†

THIS company has in use some of the world's largest and most powerful hoisting equipment. Serving 27 vertical and inclined shafts, there are 30 hoists in commission at the present time. The most unusual and interesting of them and, at the same time, the largest is the "Minong and Siscowit" at the Red Jacket shaft. (*Figure 1.*)

Designed by E. D. Leavitt and built by I. P. Morris Company, this machine comprises two steam engines of the vertical, triple-expansion, beam-engine type; two of the cylinders are 20⅛ in., two are 31¾ in. and two are 50 in. in diameter; the piston stroke is 72 in. The high pressure and intermediate cylinders are at the opposite end of the beam from the low pressure cylinder. Each engine has an independent condenser and is reversible, having the Walschaert gear. Gridiron-type valves operated by hardened steel cams are used with automatic cut-offs on the high pressure cylinders. At 180 lbs. steam pressure and 60 r. p. m., this hoist develops 3,000 hp.

The engines are directly connected to a mechanism known as the Whiting hoisting system for handling two skips in balance. The arrangement consists of two rope-driving wheels 19 ft. 1½ in. in diameter, set tandem, each carrying four "Walker differential rings" made of steel. They are so constructed that each ring is free to slip independently of the others, thereby overcoming any differential action set up between the two wheels. The hoisting rope, 1¾ in. in diameter, leaving the shaft head-sheave passes under a 16-ft. deflecting sheave and goes thence to the bottom of the wheel nearest the engine, passing beneath the front sheave enroute. To permit this alignment, the front wheel is slightly tilted from a vertical plane and since the two wheels are connected, ball and socket joints are necessary between the crank pins and the connecting rods. After making four complete turns around the driving wheels, the rope travels on rubber-filled carrier-sheaves to a tail-house where it passes around an adjusting sheave that is hydraulically operated along a horizontal track to absorb any change in the rope's length due to cutting or stretching. Returning from the tail-house on carrier-sheaves under the engine-room floor, the rope passes out and up to the other head-sheave and thence to one of the two 7½-ton Kimberley skips used for hoisting ore. The shaft is 4,900 ft. deep vertically; but, by virtue of the system just described, the length of hoisting rope required for the two skips is only 6,500 ft. Another feature of this system is the balance rope; it is a 1⅜-in. rope approximately 4,900 ft. long reaching from the bottom of one skip down to the bottom of the shaft where it passes around a balance-sheave and thence up to the other skip. This balance sheave is made of bronze, is 7 ft. 3 in. in diameter, is set in a frame that travels on guides, and has a take-up travel of about 11 ft.

The "Delaware and Iroquois" hoist is used for handling men and supplies at this shaft in two double-deck cages. The engines are horizontal, tandem-compound in type with two cylinders 16 in. and two 32 in. by 48-in. stroke. The geared drum is 25 ft. in diameter, cylindrical in form and grooved for 1⅜-in. ropes. the band brake is applied by gravity and released hydraulically; it works on basswood shoes bolted to the drum. Four other hoists of this same type are used at inclined shafts for hoisting ore, viz., No. 4 and No. 6 on the conglomerate and No. 14 and No. 15 on the Osceola amygdaloid lode.

The ore mined in the deeper levels of the conglomerate lode is all hoisted in Red Jacket shaft. *Figure 2* illustrates the style of timbering and gives the dimensions. There are six compartments, each 6 ft. 3 in. by 7 ft. The two at the east end are used for hoisting ore, the cages occupy the west ones and those in the middle were formerly given over to water-bailing but are now ladder and pipe compartments.

Ore-loading pockets, each holding a skip load, 7½ tons, are in use at the fifty-seventh and eighty-first levels. Tram cars of 7½-ton capacity are dumped into the pockets by rotary tipples. When receiving a load, the skip is placed on keeps and an apron operated by a hand lever is dropped from the pocket to the mouth of the skip. The door of the pocket is then released and the weight of the ore pushes it open; the door opening and hence the rate of discharge of the ore into the skip is controlled by a foot brake. The weight of the door causes it to close after the pocket is emptied and then the apron is withdrawn.

*Superintendent of Motive Power.
†Heading Mining Captain on Conglomerate Lode.

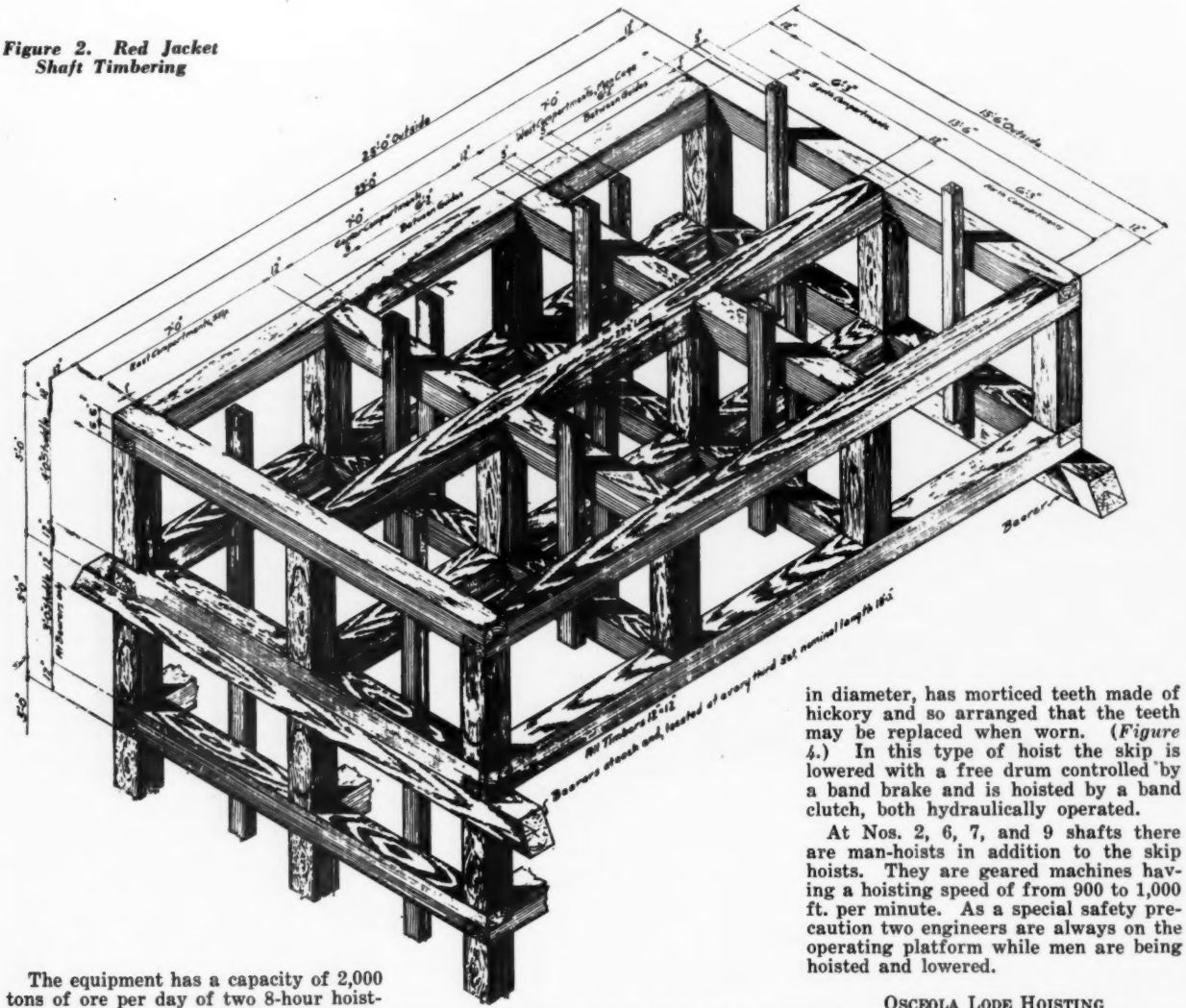


Figure 2. Red Jacket Shaft Timbering

The equipment has a capacity of 2,000 tons of ore per day of two 8-hour hoisting shifts, at a rope speed of 2,700 ft. per minute. For 18 trips an hour the hoisting cycle is 3 minutes and 20 seconds. The skip loads are automatically dumped upon aprons in the rockhouse. Located above the dump in each compartment are four safety-catches operated by springs and arranged to catch the skip in case an overhoist should break the rope. Double-deck cages with a capacity of 40 men each travel through the shaft at a speed of 1,350 ft. per minute. The cages are equipped with safety-catches that grip the guides in case of rope failure and they are further safeguarded by safety-catches placed above the top landing and similar to the skip-catches mentioned. Iron-bar roller type curtains are provided on the cages. (See *Figure 3.*)

Conglomerate Lode Hoisting

There are seven inclined shafts operating on the conglomerate lode. They are Nos. 2, 4, and 5 Calumet, and 6, 7, 9, and 12 Hecla. All shaft collars have been concreted to bed rock through the overburden which varies in thickness from 15 to 30 ft. At No. 7 shaft, which is typical of the shafts on this lode, a single skip is operated; it is built with extended rear hubs, is self-dumping, weighs 5¾ tons and has a capacity of 7½ tons. The compartment in which the skip operates is 6 ft. 6 in by 8 ft. with a 4 ft. by 8 ft. ladderway at one side. The hoisting speed for ore is 2,250 ft. per minute on an incline of 37 degrees and the daily capacity is 1,500 tons. There are two 8-hour hoisting shifts, the extra shift being devoted to shaft repair work and to handling drills, timber and supplies. A special man-car is provided with seats for 30 and is equipped with a protecting bonnet, guard-rails and safety chains. The gauge of the skip road is 4 ft. 4 in.; 50-lb. steel rails are laid on 8-in. ties, 6½ ft. long, spaced about 18 in. apart. Maple rollers 12 in. in diameter and 23 in. long with 1-in. steel spindles turning in babbitt bearings held in suitable iron-plate frames spiked to the ties are spaced 30 ft. apart. The tops of these rollers, approximately 1½ in. above the rail, carry the weight of the skip rope. Longitudinal guides of 6-in. by 8-in. fir are fastened to the ties with 13-in. lag screws outside of the rails.

The "Hancock" engine, which hoists the ore in No. 7 shaft, is of the vertical rocker, triple-expansion, 3-crank type with cylinders as follows: 20⅛-in., 31¾-in. and 50-in. by 48 in. stroke. A 25-ft. cylindrical drum grooved for a 1⅜-in. rope is driven through a set of spur gears. The large gear, which is 30 ft. in diameter, has morticed teeth made of hickory and so arranged that the teeth may be replaced when worn. (*Figure 4.*) In this type of hoist the skip is lowered with a free drum controlled by a band brake and is hoisted by a band clutch, both hydraulically operated.

At Nos. 2, 6, 7, and 9 shafts there are man-hoists in addition to the skip hoists. They are geared machines having a hoisting speed of from 900 to 1,000 ft. per minute. As a special safety precaution two engineers are always on the operating platform while men are being hoisted and lowered.

Osceola Lode Hoisting

Shafts 13, 14, 15 and 16 on the Osceola lode are in operation to a depth of 4,000 ft. or more on a dip of 37 degrees. The skips are handled in balance; each has a capacity of 7½ tons, weighs 5½ tons and is of the usual self-dumping type with extended rear hubs. Hoisting ropes are 1⅜-in. plow steel, 6 strands of 19 wires, ordinary lay. Shaft rollers are of wood 12 in. by 23 in. In general the equipment and methods are similar to those of the conglomerate lode just described.

Nordberg, first motion, 32-in. by 72-in. hoists are used at No. 13 and No. 16 shafts. Each has one cylindro-conical drum 18 ft. 6 in. in diameter at the middle with a 16-ft. face grooved for 1⅜-in. ropes. These engines and drums are capable of hoisting from a depth of 6,000 ft. at a rope speed of 2,800 ft. per minute. The undershoe brakes are applied by gravity and released by steam. Ten-foot, wood-filled, angle and head sheaves are standard while idler sheaves are rubber-filled. The hoists at Nos. 14 and 15 are exactly like the "Delaware and Iroquois" installation described as the man-hoist at Red Jacket shaft. (See *Figure 5.*) They can operate to a depth of 6,000 ft. on this lode at a speed of 2,250 ft. per minute.

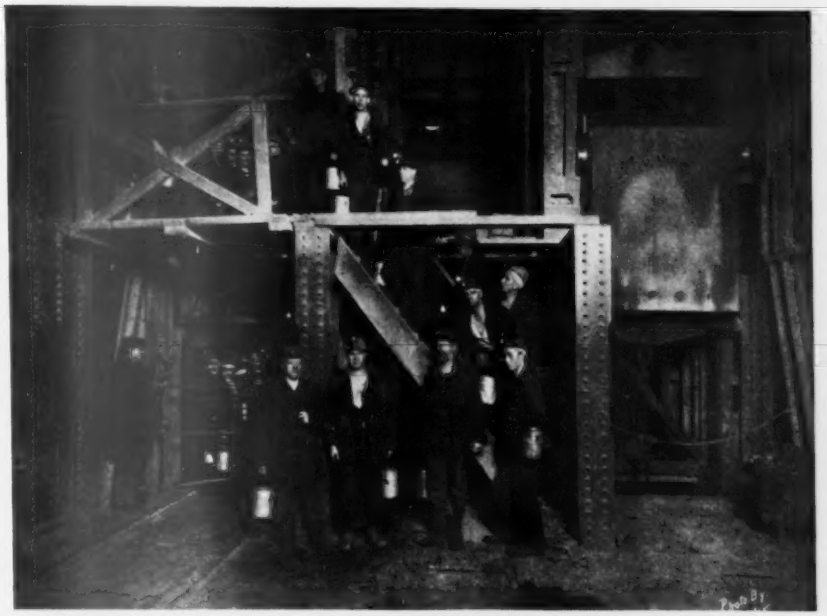


Figure 3. Double-deck cage and skip, Red Jacket Shaft

"A" AND "C" SUBSHAFTS

Shafts designated as "A" and "C" have been sunk below the eighty-first haulage level and are served by electric hoists, similar in design, manufactured by the Allis-Chalmers Manufacturing Company. They are located at the eighty-first and seventy-eighth levels, respectively, and hoist ore from the ninety-sixth level—the deepest workings of the conglomerate lode. Each is a single-drum, geared hoist of the Ilger system with an individual sub-station; the electrical drive consists of a 500-hp., 250-volt, 700-r. p. m., d. c. motor. Current is supplied by a motor-generator set made up of the following units: a 400-kw., 250-volt, d. c. generator; a 500-hp., 440-volt, 3-phase, 25-cycle induction motor; a 9-kw., 125-volt, direct connected exciter. The hoisting drum is 5 ft. in diameter with 6-ft. face; it is made of cast-iron with two supporting spiders and a brake-wheel and has a capacity of 3,000 ft. of 1-in. rope. The brakes are post-type with basswood block lining, parallel motion; they are released by gravity and applied by hydraulic power. The drum shaft is 10 in. in diameter, made of nickel steel. The pinion is forged integrally with the pinion shaft; it has a 9-in. face and 21 teeth. The gear has 157 teeth of the Falk double-heiical type and is made of cast steel. (See *Figure 6*, photo of "C" shaft hoist.)

Subshafts "A" and "C" are inclined 35 degrees from the horizontal, 9 ft. by 14 ft. in size, each with one skip road and a ladderway. Four tons of ore are hoisted per trip at the rate of 1,450 ft. a minute; the lowering speed is 1,725 ft. The maximum weight on the rope is approximately 12,800 lbs. At "C" shaft the skip in use is of the usual type, self-dumping through the front end. At "A" shaft the head room necessary for that style of dump was not available; hence a specially designed skip was constructed with a rounded rear end fitted with a movable cover or door that lifts up as the skip reaches the dump, and the ore slides out through the opening. (See *Figure 7*.) Model "D" Lilly controllers are fitted to these hoists to prevent over-winding and excessive speed.

CENTENNIAL AND AHMEEK SHAFTS

The Centennial mine has two shafts in the Kearsarge lode, sunk on the incline. At surface they are only 150 ft. apart and are in parallel alignment for 1,000 ft. in depth, but at that point No. 2 shaft is deflected 9 degrees and 20 minutes to the north away from No. 1 and continues downward in the plane of the lode at approximately 38 degrees below the horizontal.

At the upper end of the main curve a horizontal sheave deflects the rope laterally toward the right as the skip passes down the shaft. This is a cast-iron sheave 21 in. in diameter, supported in a steel plate frame bolted to the cross-ties. Its periphery is set 1½ in. to the right of the shaft center line and its housing projects 2 in. above the rail-head. Five vertical deflecting rollers, 40 ft. apart, prevent the rope from striking the wall of the shaft when the skip is below the curve. These rollers are 16 in. in diameter by 13¼ in. long, supported in steel plate frames, well braced and fastened to the cross-ties. A pair of rollers 12 in. by 15½ in., running on horizontal shafts, are located opposite each vertical roller. Between the horizontal rollers hardwood blocks are placed to guide the rope over the right-hand shaft rail onto a pair of inclined rollers, which in turn guide the rope to the vertical deflecting roller. These inclined rollers are 12 in. by 12½ in. and are supported by an inclined cast-iron frame. All shaft rollers are set 2 in. below the top of the rail and the clearance between the skip-body and the rail-head is 3¼ in.

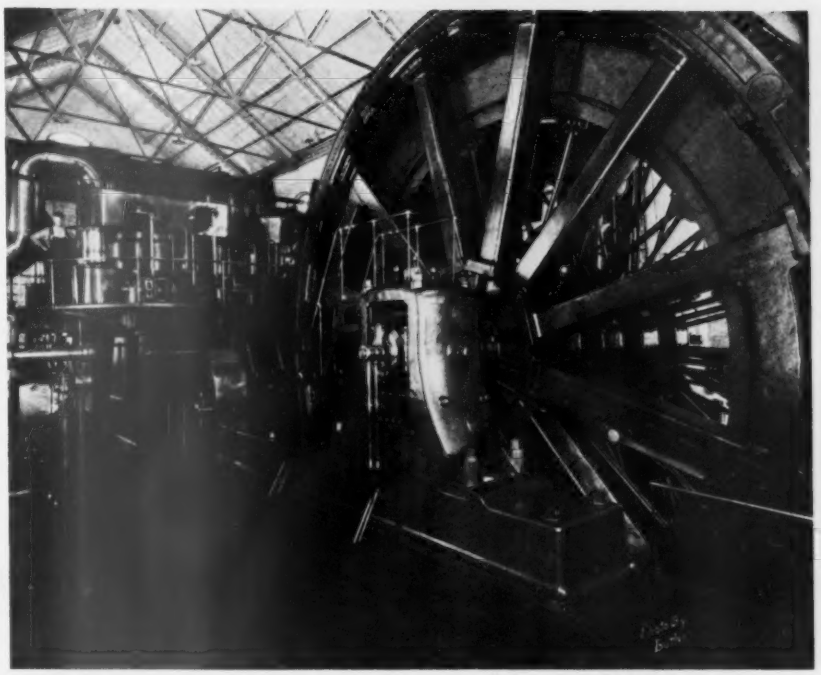


Figure 4. Hoisting engine, Conglomerate Lode

To prevent derailment a 5½-in. by 7½-in. maple guide-timber is located inside of the left-hand rail. This engages suitable guide-shoes on the under side of the skip near the left-hand wheels. The guide-timbers, which are extended 15 ft. beyond the end of the curve, have tenoned joints and are lag-screwed to the cross-ties just flush with the top of the rail. The guide-shoes are brass castings bolted to heavy steel castings which are riveted to the bottom plate of the skip. Clearance between guide and shoe

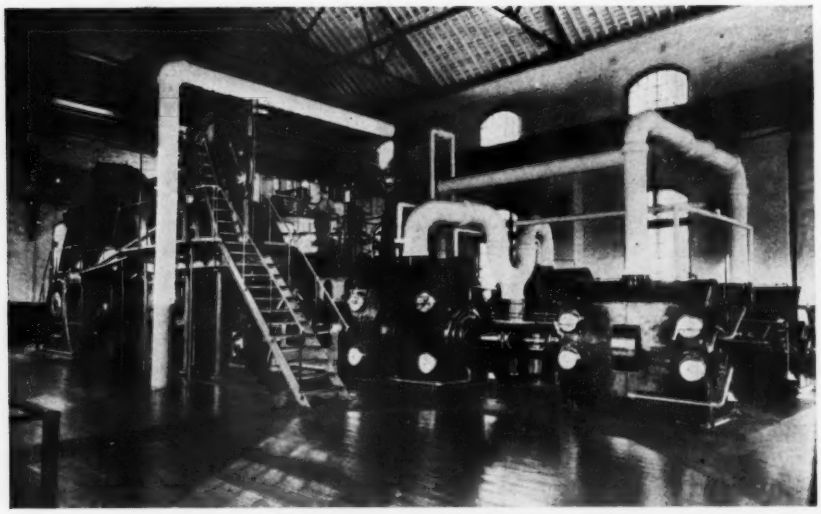


Figure 5. No. 14 Osceola Lode Shaft

is 7/16 in. at the sides and 2 in. at the top. All sheaves and rollers are rubber covered and are fitted with graphite-lined, bronze bushings, pressed in; they revolve on cold-drawn steel shafting. (*Figure 8.*)

Shafts 3 and 4 of the Ahmeek mine are located about 1,400 ft. west of the outcrop of the Kearsarge lode. The collars of the shafts are close together and a common shafthouse handles the ore from four hoisting compartments. In order to develop the territory tributary to these shafts, it was necessary for No. 4 to rake about 19 degrees north and for No. 3 to rake about 22 degrees south of a plane normal to the strike; hence the distance between the shafts increases as depth is attained. The dip of both shafts from surface to a point 980 ft. below the collars is 80 degrees; from that depth by means of spiral easement curves, the shafts are gradually brought into the vein to a dip of about 35 degrees. *Figure 9* is a plan and section showing the general layout.

Each shaft has three compartments—two skip roads and a ladderway—the skip-roads being 6 ft. 10 in. by 7 ft. 6 in. and the ladderway 3 ft. by 7 ft. 6 in. The skip-roads are fitted with guides set above the top of the skip wheels to keep the skips on the track in the steep portion of the shaft. Around the curved portion back-sheaves are provided to carry the hoisting ropes.

Safety Equipment

The designs of the hoists and the conditions under which they operate have required a number of special features to secure proper functioning of the Lilly controllers used on all hoists. All the

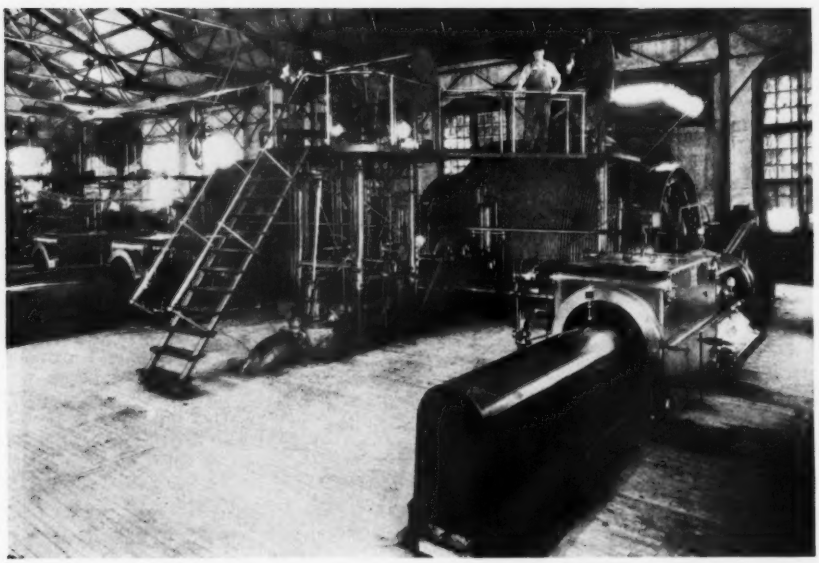


Figure 8. No. 3 Ahmeek Hoist Shaft

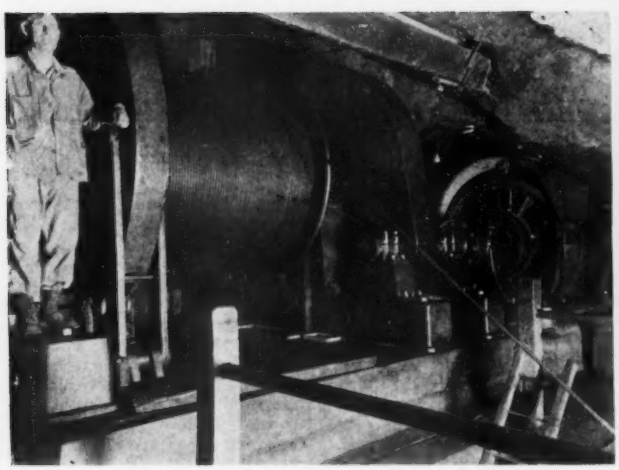


Figure 6. "C" shaft hoist, 78th level

Figure 7. "A" Shaft skip

CALUMET AND HECLA CONSOLIDATED COPPER COMPANY

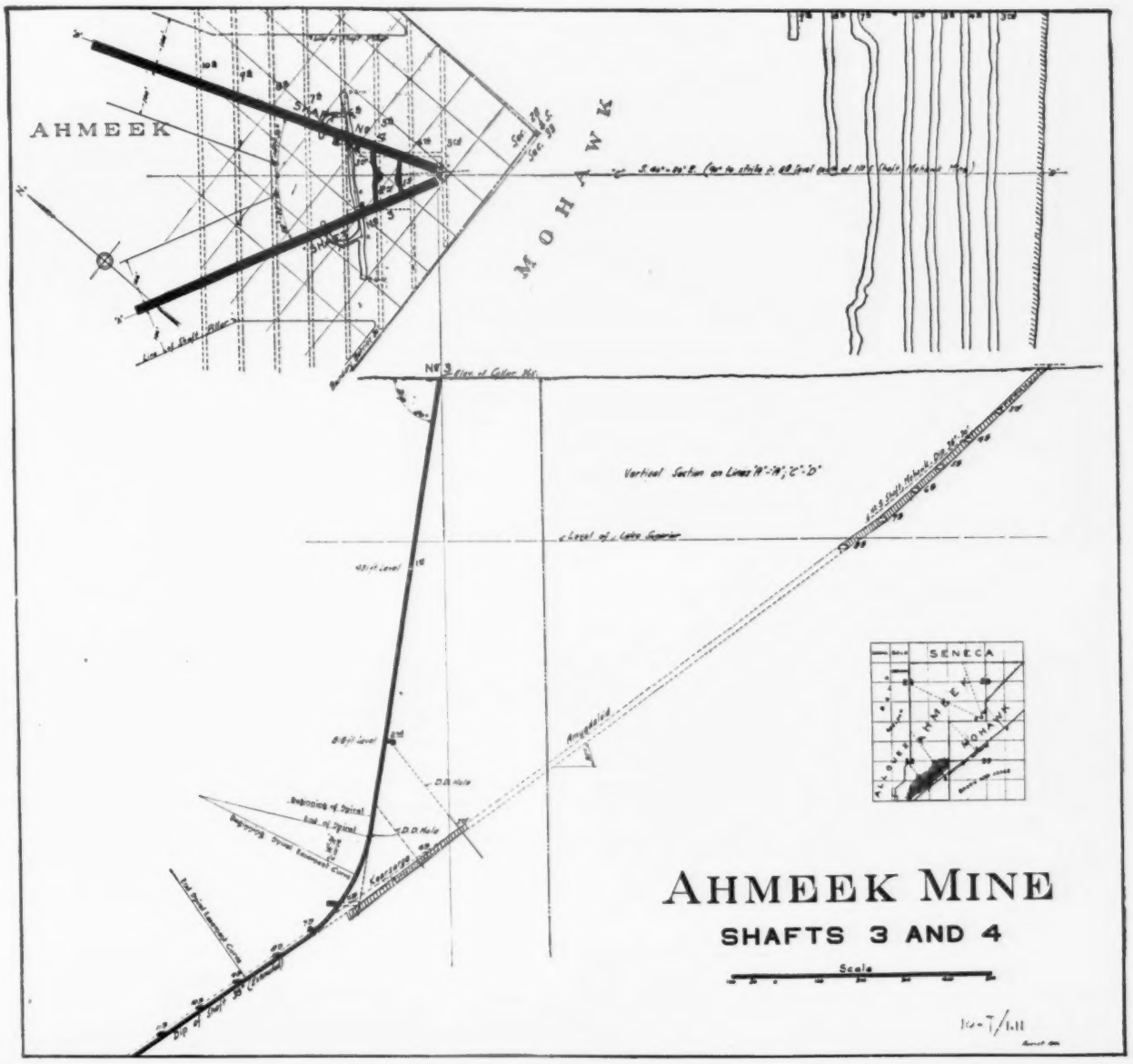


Figure 9

large surface hoists handling ore are equipped with the Model "C," while all others have the Model "D." They give the usual protection against overspeeding and overwinding at the limits of travel, with regulation of the brakes to prevent severe application at high speeds and to give a quick application toward the ends of the trip where the retardation of speed must be conducted within the limits of safety. Electric bells warn the operators if normal speed is exceeded and single-stroke gongs give warnings at the points where retardation must commence. On all hoists handling men the controllers are equipped with extra safety devices to compel operation at reduced speed and prevent overtravel of the man-landing limits.

Some of the special safety features in connection with the standard equipment are: switches to limit the travel of drill and supply trucks above the run-off rails, and "brake and reverse interlocks" to guard against starting in the wrong direction when the skips or cages are at the limits of travel. This "brake and reverse interlock" is a special unit mounted on the operator's platform and comprises a solenoid-operated latch and a ratchet plate connected to the brake lever. Four switches, two operated by the reverse lever and two by the skips, are so connected that when one skip enters the dump it opens the circuit that drops the solenoid latch and prevents the operator from releasing the brake again until the reverse lever is placed in position to start the hoist in the proper direction. (See *Figure 10.*) The brake can be applied at any time but can be released only by placing the reverse lever in the proper position, but the latter is free to be operated at any time. All safety equipment is electrically operated on the closed circuit principle.

Electric Bell Signal System

The bell system has two sets of gongs at the hoist and one in the rockhouse, each set consisting of two gongs of different tones operating on 110-volt a. c. current. (See *Figure 11.*) A signal of "one bell" consists of the striking of one gong by a solenoid plunger when the solenoid is energized and the striking of the other when it is released. As the skip approaches the dump, the attendant pulls down the signal bob and one gong is struck; this is called a "half-bell." When the skip has reached the desired dumping position, he releases the bob; this rings the other "half-bell" and the engineer stops the hoist. One set of gongs on the engineer's platform is operated from the surface and one set from the mine; thus the engineer always knows the source of the signal. (See *Figure 12.*)

A light signal system is operated in connection with the bell system and con-

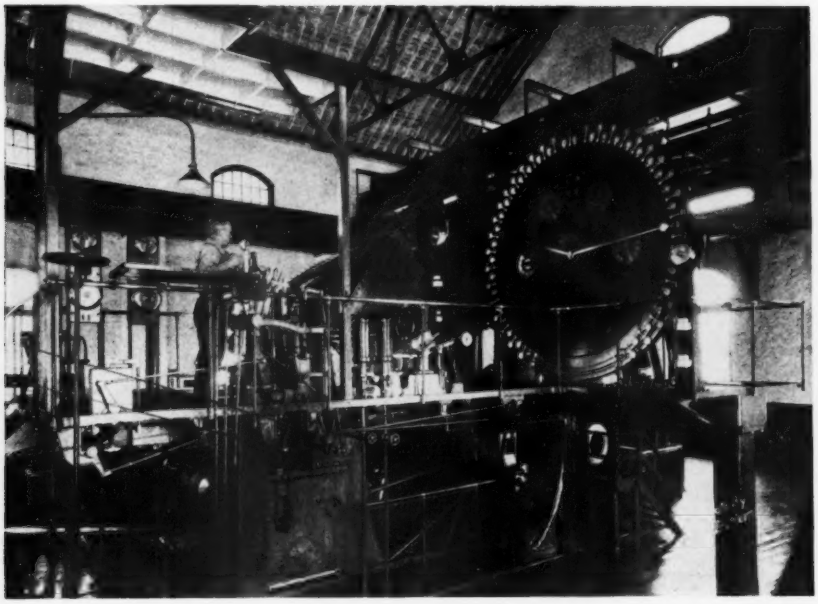


Figure 12. Hoisting engine, No. 15 Osceola Lode shaft, showing Lilly hoist controller and electric signal system

sists of one green and two red lights arranged vertically at the hoist and one red light in each pull station at the collar and underground. These lights are operated by switches attached to the solenoid plungers on each set of hoist gongs and so connected that one red light at the hoist and all mine lights are operated by any mine signal station. All other red lights are operated by surface controls. The green is normally on when no signal is being given; it indicates that both shaft and surface are clear for operation.

Each pull station consists of an enclosed box containing a switch for ringing the signal and a light operated by the solenoid plunger; thus the person ringing, as well as any one near any other station, can see exactly how many bells are struck.

In case work is underway in the shaft and movement of the skip would be dangerous, the "pull station" switch is closed and locked; thus the engineer and others at the shaft stations are all warned of danger by means of the red signal light. Should the engineer receive a signal from surface, he is not permitted to move the hoist until the green light indicates that the mine system is clear. This works vice-versa in case of interference at the surface. In addition to the signal system, a telephone system with phones located at the loading stations is used for communicating with the engineer.

Hoisting Ropes

Plough-steel and extra strong crucible 6 by 19 ropes are used entirely for hoisting, the plough-steel being used on all hoists handling men. Regular inspections are made and a detailed record kept of each rope from the time it is put into service until it is scrapped. All ropes are resocketed every four or five weeks, depending on working conditions, and several feet are cut off. The open type socket is used entirely. The average life of ropes on the ore-hoists is 12 months, while on the man-hoists it is 18 months. Due to more severe hoisting conditions at the Ahmeek branch, however, the average life of ropes is only nine months.

Each rope is changed end for end when it has been in service half its expected life. Owing to the great length and weight of the cables, a portable reel-stand, designed to facilitate the work of making these changes and of removing condemned ropes from service, is regularly employed. The stand is of heavy timber construction and equipped with suitable bearings into which the shaft of the rope reel is mounted. A two-cylinder engine drives the reel through reduction gears. This device may be operated by either steam or compressed air. The heaviest cable used, 6,500 ft. in length, 1¾ in. in diameter and weighing over 15¾ tons, has been removed and a new rope reeved through the Whiting hoisting system at the Red Jacket shaft in less than eight hours with this equipment.

All ropes are treated with hot lubricant every three weeks. The split-box method is used for lubricating outside the hoist rooms, while a specially designed air-operated spray-gun is used to apply lubricant to ropes on the drums.

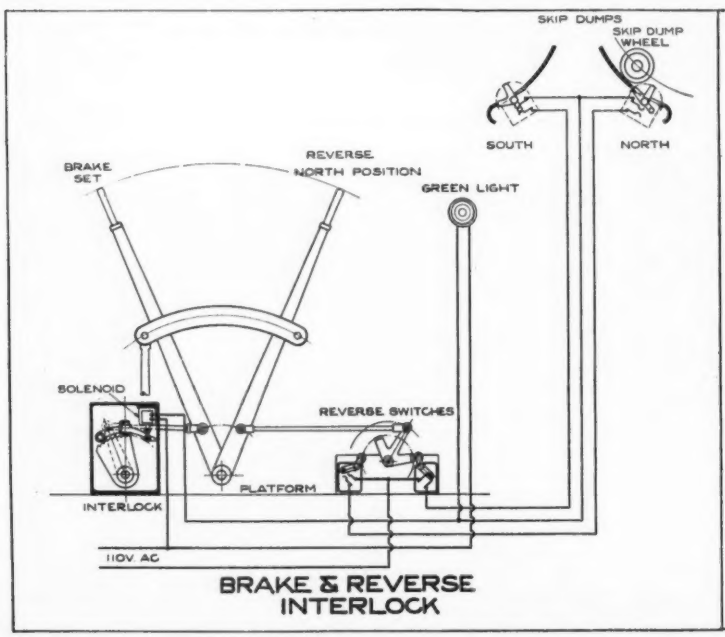


Figure 10

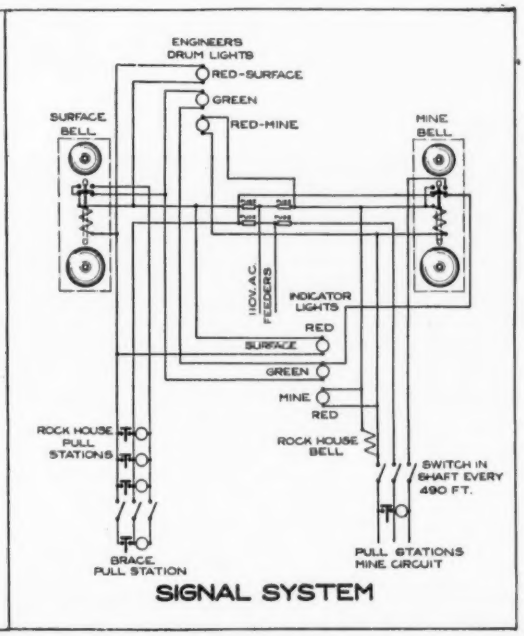


Figure 11

Transportation System and Coal Dock

Figure 1. First Calumet Mill, 1867.

Figure 2. Old incline to Calumet Mill on Torch Lake, 1867 to 1886.

By Frank H. Haller*

WHEN the copper mines in the Keweenaw Peninsula of northern Michigan were opened in the 60's or earlier the nearest railroad was at Green Bay, Wis., 220 miles away and any mining company requiring transportation facilities was compelled to create them. Fortunately, however, most of the mines were within a few miles of harbors on Lake Superior or its inlets, such as Portage Lake and Torch Lake, which permitted shipments of machinery and supplies to be made in the summer by boat, from manufacturing centers on the lower lakes. These were delivered to the mines after comparatively short hauls over wagon-roads or tram-ways; but during the season of closed navigation on the lakes, absolute necessities had to be teamed all the way from rail transportation terminals. Shipments of copper from the mines were made in the same fashion, by boat or by long overland hauls. All-rail traffic into and out of the copper district of Michigan was not possible until the Marquette, Houghton & Ontonagon railroad was completed in the fall of 1883, more than 17 years after the Calumet mine was opened. In the meantime the custom of shipping everything possible by lake vessels became firmly established and, until a few years ago, the greater part of the copper shipped from Michigan refineries went out by boat. Today the docks on both Portage Lake and Torch Lake are readily accessible to the largest of the Great Lakes carriers and all shipments of coal as well as other bulk and package freight are received by boat. (See maps.)

The first stamp mill for the Calumet mine was only a short distance away and the ore was hauled to it in horse-drawn tram-cars. (See *Figure 1.*) The first mill for the Hecla mine was located on Torch Lake and the "Hecla and Torch Lake" railroad was built in 1867 to connect it with the mine. This railroad was four and three-quarters miles long ending at the head of an incline of variable pitch, a mile long, the lower end reaching to the ore-bins of the mill. The grades of the incline were much too steep for the locomotives that operated on the railroad; but the loaded cars going down drew the empties up by means of wire rope connections—a method then commonly used at several properties in the district. (See *Figure 2.*) Incoming supply shipments by lake vessels were unloaded at a dock on Torch Lake and hauled to the mines over this railroad. The gauge of the track was 4 ft. 1 in., the cars were four-wheeled boxes carrying 2½ tons of ore, and the locomotives were very small. After some years the Hecla mill was enlarged, a new Calumet mill was built close to it, mine production was increased, cars carrying double the tonnage were built and larger locomotives were purchased; but the old incline continued in commission for 19 years. About 1885 a better

* Superintendent of railroads.

Figure 3. American Consolidated type locomotive and train of loaded 40-ton ore cars.

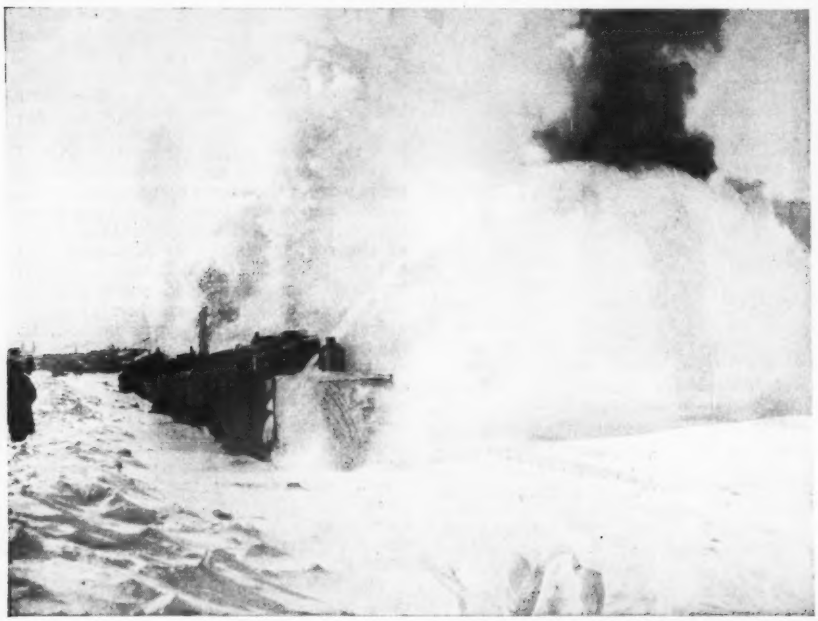


Figure 5. Clearing railroad tracks in a climate where the normal snowfall is 8 or 9 feet each winter.

location for the lower end of the railroad was determined upon; the new route added somewhat to its length but greatly reduced its grade and made possible the use of locomotives all the way. The incline was finally abandoned in 1886. By 1906 the company's plant at Calumet and its mills and smelter on Torch Lake had very greatly expanded; extensions and sidings of the railroad had been built at a rapid pace to keep up with the increasing business, but the small cars were a tremendous handicap; finally it became fully evident that larger cars of an up-to-date design, using air-brakes and standard couplers, were absolutely essential. An order for 140-ton ore cars of steel and wood construction was given to the American Car and Foundry Company; these were specially designed to negotiate the sharp curves established years before in and around the buildings. All tracks were changed to standard gauge, 4 ft. 8½ in.; a dozen or more locomotives were broad-gauged as well as all the flat cars, mineral cars, etc., in use at that time. This work was accomplished without interfering with production from the mines.

Since then the Calumet and Hecla railroad (still spoken of as the Hecla and Torch Lake) has continued to grow both in equipment and in tonnage handled but has remained a private industrial system. Its main line is five miles long from the mines to the mill yards and is laid with 90-lb. and 80-lb. steel. At the Calumet end it has extensions, branches and sidings totaling 22 miles of track laid with 80-lb., 70-lb. and 60-lb. steel. At the lake end it serves the various mill buildings, the smelter and the coal dock with 10½ miles of branches and sidings. The rolling stock consists of 250 hopper-bottom ore cars of 80,000-lb. capacity; 19 all-steel, 100,000-lb., bottom-dump mineral cars; 35 steel, 8-ton mineral cars; 90 wooden, 12-ton, side-dump, waste-rock and ash cars; 35 wooden flats and gondolas; 6 steel, 12-yd., Western air-dumpers; 6 wooden, 30-ton box cars, and three passenger coaches for occasional service in carrying employes to and from work.

In 1923 the Ahmeek, Kearsarge, Allouez, Centennial and Osceola mines were merged with Calumet and Hecla and, being without railroads of their own, shipped their ore by the Mineral Range railroad from mines to mills over an indirect route with heavy adverse grades. The tariff rates were so high on this line that, during and after the working out of the consolidation, much serious thought was given to planning a more direct route with moderate grades, to be built and operated by the Calumet and Hecla Consolidated Copper Company and in 1925 this railroad was completed; It is 9½ miles long from the Ahmeek mine to the mills at Torch Lake. Several miles of branch track, 100 steel, 50-ton ore cars, 2 consolidation-type locomotives weighing 206,000 lbs. each (See *Figure 3*), and other auxiliary equipment were purchased from the Mineral Range railroad for the new line, the whole being spoken of locally as the Trap Rock Valley railroad. In addition to the new track, laid with 80-lb. steel,

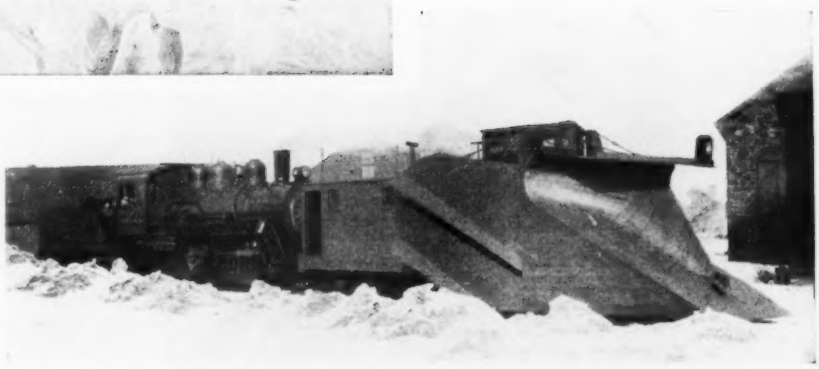


Figure 6. No. 2 Russell snow plow with wing elevators and flanger.

COPPER, ORE, COAL, MINERAL, ETC., HANDLED

Year	Copper ore to mills	Coal from dock to mines & mills	Mineral to smelt.	Waste rock to dump	Sundry commodities moved	Total tonnage handled
1926	2,363,933	426,696	98,697	58,266	137,000	3,084,792
1927	2,754,358	436,399	94,911	104,197	127,425	3,517,290
1928	3,073,382	436,964	104,218	137,021	190,175	3,941,760
1929	3,150,110	445,876	104,475	137,659	177,025	4,015,145
1930	2,951,475	401,879	87,648	151,821	149,250	3,742,073
Total	14,293,258	2,147,814	490,149	588,964	780,875	18,301,060

there are now 11¾ miles of extensions and sidings laid with 80-lb. and 70-lb. steel at the mines and mills. This line connects with the Hecla and Torch Lake railroad and both are operated as one system.

In spite of the rugged, hilly country traversed by the new railroad, a maximum allowable grade of 6/10ths percent and a maximum curvature of 8 degrees was adhered to in construction. The average grade is 35/100ths percent and favors the loads at all points. Aside from two concrete and steel viaducts over an interurban car line and a state highway, there are no bridges on the line except the steel trestle approach to the Ahmeek mill. (See *Figure 4.*) There are, however, many galvanized, corrugated metal and reinforced concrete culverts and many heavy fills. Necessary earth and rock cuts averaged 36,810 yds. per mile; fills average 63,035 yds. per mile, the extra material in most cases being obtained by widening the cuts.

Conditions in the copper industry have been such that traffic handled on the Trap Rock Valley line has never approached the tonnage counted upon when it was planned. Nevertheless, the unit cost of transportation has been below the expected figure, and during the five years of operation (up to the fall of 1930), the savings to the company on actual tonnage hauled have been well over a million dollars, which more than repays the entire cost of construction and equipment.

As stated above, the old railroad and the new are operated by the mining company as one system with 14½ miles of main line and over 44 miles of branches, extensions and sidings. To keep these tracks cleared for action at all times in a climate where the normal snowfall is 8 to 9 ft. each winter is not a small task. (See *Figure 5.*) Permanently erected snow-fences are necessary in many places, including the yards around the mines, and substantial snow-plowing equipment is required. A No. 2 Russell plow with wing elevators and flanges is used for single-track lines, while six smaller plows of various types, with adjustable wing-spread, are kept for clearing yards where two or more tracks lie parallel. (See *Figure 6.*) Three locomotive cranes (a Brownhoist and two Industrials) with extra large clam-shell buckets are also used for moving snow banks. (See *Figure 7.*)

All copper ore, mineral, coal, etc., handled in the mining company's operations is weighed on standard railroad track scales. At the approaches to the stamp mills there are three 75-ton Fairbanks scales with Streeter-Amet automatic tape recording attachments; at the coal dock and the smelter there are three installations with Howe patent recording beams.

The round-house at Calumet is a stone and steel structure having stalls for 15 locomotives and repair pits for two more in a shop adjoining. At convenient points around the mine and mill plants there are three locomotive coaling stations and six water supply stations. (See *Figure 8.*) The dispatching of trains is accomplished by telephones connecting eight make-up yards, terminals and junction points. A well equipped car-repair shop is maintained at Calumet adjacent to the mine shops and foundry.

The amount of copper ore, coal, mineral, etc., handled during the past five years is shown in the table on page 516 in tons of 2,000 lbs.

Above—Figure 4. Steel trestle approach to the Ahmeek Mill.

Left—Figure 7. Locomotive crane with extra large clam shell for loading snow or ashes.

Figure 8. Coaling station and water tank, and two Trap Rock Valley locomotives at Ahmeek.

Coal Dock

An old type of apparatus used for unloading coal from boats about 45 years ago is shown by *Figure 9.* Like others, it served its intended purpose for a period and then made way for something better.

The coal-handling bridge now in use was furnished and erected by the Mead-Morrison Manufacturing Company and went into commission in the summer of 1918. The bridge is equipped with a man-trolley operating a 9-ton automatic grab-bucket and two loading-out hoppers mounted in the supporting towers or "pier-legs." The man-trolley carries the traveling and hoisting motors, the drums and brake mechanism and the operator's cab, which is suspended in a convenient

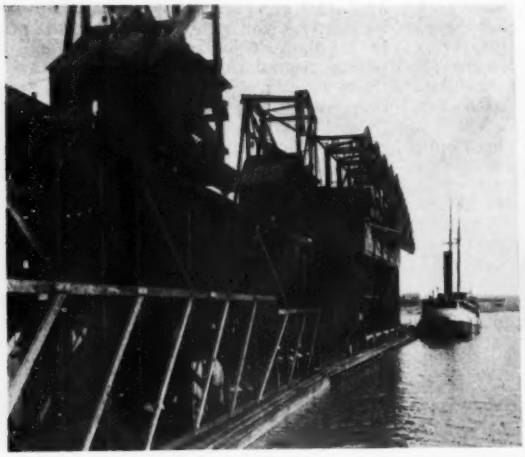


Figure 9. Old coal dock in use 40 or 50 years ago on Torch Lake.

Figure 10. The coal bridge and dock from the lake. The boat in the foreground is the "Hansa" discharging a cargo of Belgian pebbles.

position for clear observation. The entire bridge travels at the rate of 60 ft. per minute lengthwise of the dock on four 100-lb. steel rails. The total weight is supported on 32 30-in. diameter wheels similar in pattern to standard car wheels. (See *Figures 10* and *11.*)

The main bridge span is 382 ft. 6 in. in length, the cantilever overhanging the rear leg being 116 ft. long and the extension toward the lake 37 ft. in length ending vertically above the face of the dock at which point the "apron-end" is pivoted. This overhangs the water 75 ft. beyond the face of the dock, permitting the trolley to run out to points vertically over boat holds and may be swung up to a vertical position over the dock face so as to offer no obstruction to ship masts, etc., when vessels are being shifted along the dock. The bottom chord of the main truss is 70 ft. vertically above the dock level and the clear space below the bucket allows 47 ft. for storage.

The scheme of operation is both simple and economical. A coal boat with a cargo of 8,000 or 10,000 tons ties up alongside the dock, the apron is lowered over the boat, the bridge is moved to the right position over a hatch, and unloading gets underway quickly at the rate of 300 to 600 tons per hour depending on the discharge point of the grab-bucket. The longitudinal storage space under the main span is about 1,400 ft. long, having capacity for 475,000 tons with additional space available under the cantilever for about 60,000 tons. When delivering freely from the hold of a ship to the hopper in the front pier-leg, with sufficient railroad cars available for loading, the capacity of the equipment is over 600 tons per hour. Ordinarily, however, during the 20 or 24 hours required to completely unload a boat, only 1,000 or 1,200 tons is put into cars, all the rest being dropped on the pile. In the intervals between the arrival of cargoes or in winter, the coal in storage is reclaimed by the same 9-ton bucket that is used in unloading boats. There are two railroad tracks along the dock front for loading cars from the front hopper and another track at the rear, as shown in the larger picture, *Figure 11.*

It is not customary to use all the stock-pile space for steam coal. At the north end there is a bin of 4,000-tons capacity for storing Danish pebbles which are used in the milling operations. *Figure 10* shows the bridge unloading a cargo of pebbles. At the south end of the dock considerable space is taken by piles of anthracite, crushed limestone and coke screenings, so that the room available for storing steam coal has a capacity of approximately 400,000 tons.

Both automatic and manually operated rail-clamps lock the bridge structure to the abutments except during the few moments required to move from hatch to hatch or from one part of the pile to another. Safety devices are installed, however, to prevent any movement at all when the wind velocity is excessive. A recording anemometer placed on the top chord of the bridge is arranged to operate visible warning signals and to break the traversing power circuit when the wind is excessive; in fact, if the bridge is traveling safely and a strong gust of wind comes along at a dangerous velocity, the mechanism controlled by the anemometer shuts off the power and applies the rail-clamps instantly.

Another important provision in the operation of this bridge is the magnetic switch controller or automatic skew-limit device. With everything in its normal position, both ends of the bridge will travel in the same direction at the same speed unless one end is retarded by wind effects, friction or dragging rail grips. In case one end does lag, the skew-limit slows down the leading motor until the ends are again even. By proper manipulation of the master switches, either end may be operated in either direction without danger of skewing too much because the automatic device assumes control when one end lags more than 22 ft. behind the other. Inasmuch as the flexibility provided in the bridge design would permit one tower to move approximately 65 ft. ahead of the other, there is left a wide margin of safety and certainty in operation.

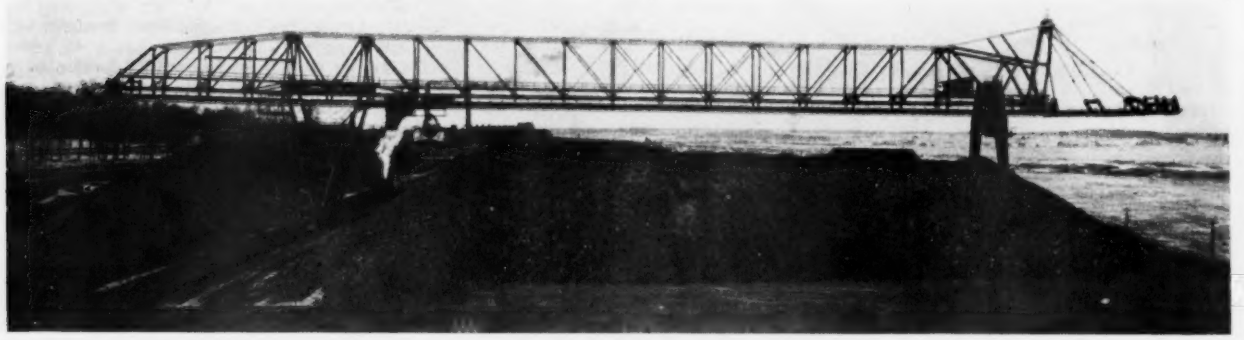


Figure 11. View of coal piles and bridge from south end.

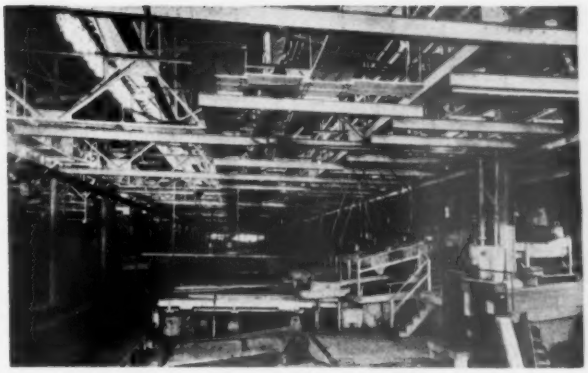


Figure 3. Calumet stamp mill, Lake Linden

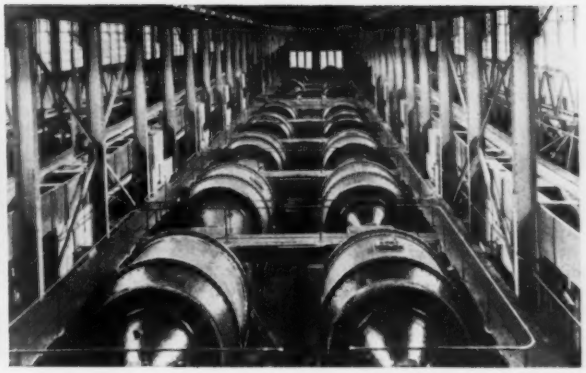


Figure 4. No. 1 regrinding plant, Lake Linden

MILLING

at the Calumet & Hecla Consolidated Copper Company

By

C. H. Benedict*

THE present operating mills of the Calumet & Hecla Consolidated Copper Company† are all located along the borders of Torch Lake. The maximum rail haul from the mines does not exceed 10 miles so that transportation costs are low. The lake itself is some four miles long and from one to one and a half miles wide, is quite deep for an inland body of water and therefore affords ample storage for tailings, and is surrounded by gently sloping hills. It has been an ideal location for both the concentrator for current production and for the reclamation plants.

The mills are in three groups. At the north end of the lake, contiguous to the town of Lake Linden, are the original mills for treating conglomerate ore. These are known as the Calumet and the Hecla, respectively, of 11 and 17 stamp units each. These stamps when

* Chief Metallurgist.

† The Conglomerate mills of the Calumet & Hecla Consolidated Copper Company have been described recently in "I. C. 6364 Department of Commerce," to which the interested reader may refer for such details as may not be given in this paper.

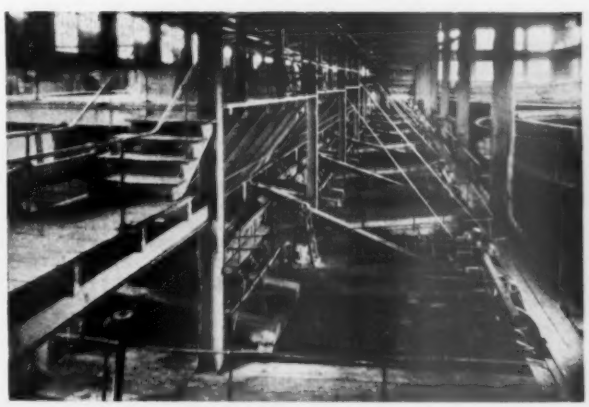


Figure 5. Leaching plant classifying system, Lake Linden

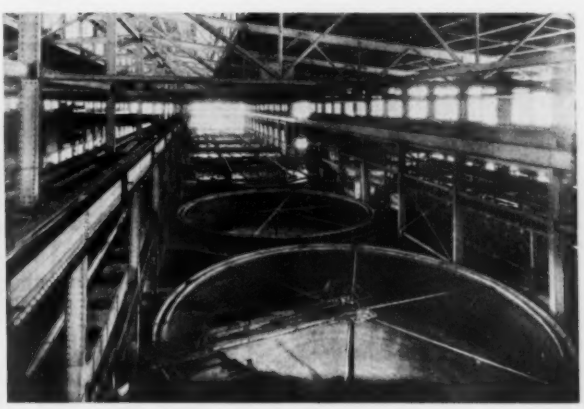


Figure 6. Sand leaching tanks in leaching plant, Lake Linden

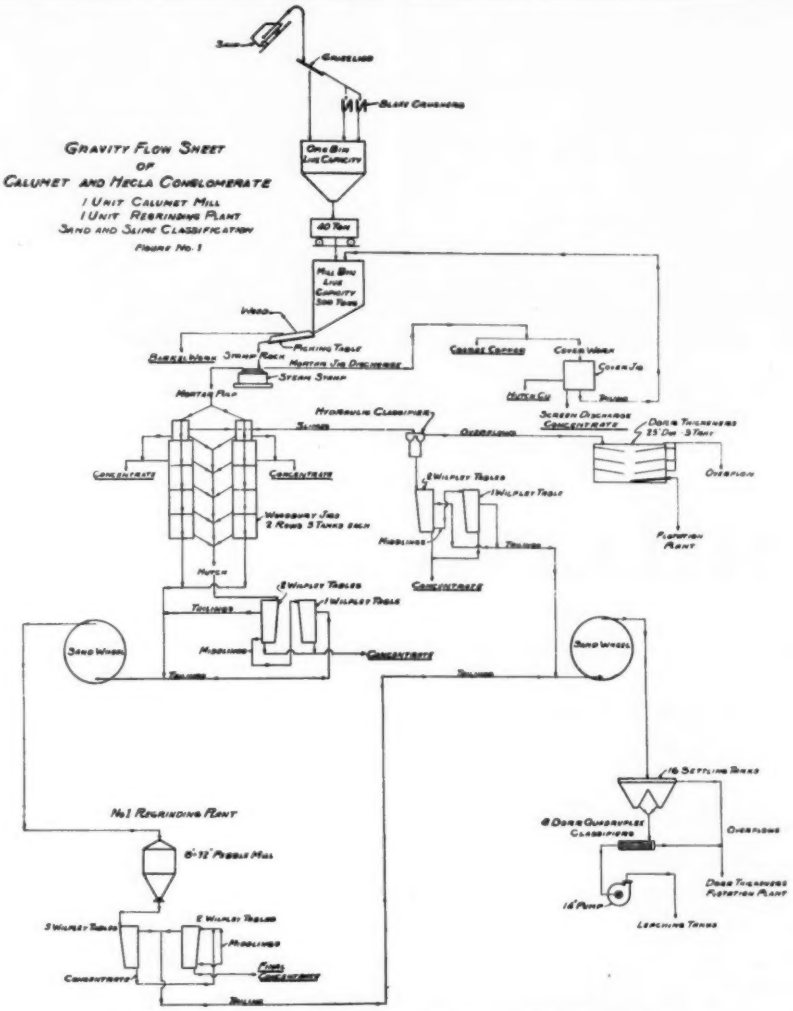


Figure 1. Gravity flow sheet of Calumet Conglomerate

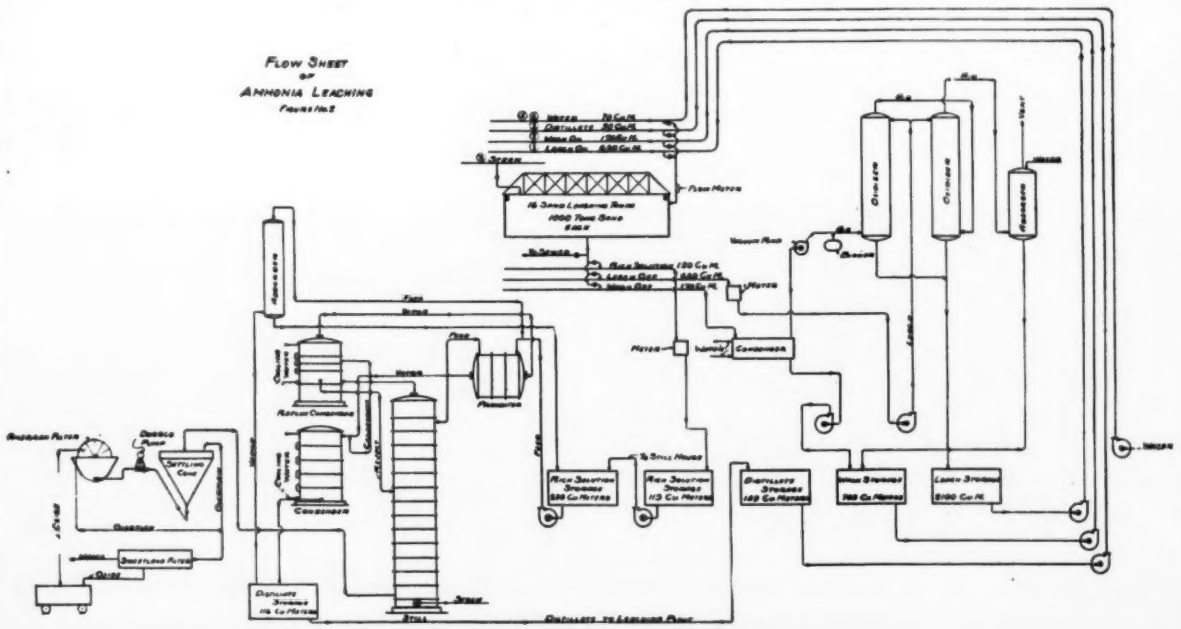


Figure 2. Flow sheet of ammonia leaching plant

CALUMET AND HECLA CONSOLIDATED COPPER COMPANY

operating on conglomerate have a daily capacity of some 350 tons and when operating on amygdaloid a capacity of 450 tons per 24 hours. The reclamation plant for treating old tailings is an integral part of this mill site, and some of the treatment plants, those used for leaching and flotation, treat both mine product and the corresponding product that has been dredged out of the lake. The coal docks and smelter adjoin these mills on the south and about half a mile south of these in turn is the principal mill of the district treating amygdaloid, the Ahmeek.

This Ahmeek mill consists of 8 stamp units of a total capacity of 6,500 tons daily, and at present this mill is treating practically all of the amygdaloid ore that is being produced under the current curtailed operating conditions. Half a mile south of the Ahmeek mill is another group consisting of the Tamarack reclamation plant and two stamp mills, the 7-unit Osceola mill and the 4-unit Lake mill. These latter two mills have a combined capacity of some 8,000 tons and are called upon for operation as the product increases beyond the capacity of the Ahmeek plant.

The conglomerate and amygdaloid ores, although similar in that native copper is the only economic mineral present, are so different in the physical nature of the gangue and in the distribution and size of copper particles that decided variations in metallurgical practice are necessary. Also the two amygdaloids that are worked at the present time by the Calumet & Hecla, namely, the Kearsarge and the Osceola, differ quite markedly not only in the richness of the ore but also in the nature of the distribution of the copper as regards size, so that here too there are variations in practice made necessary particularly by the prevailing low price for copper.

At the present time the only operating plant on conglomerate ore is the Calumet mill of the original Calumet & Hecla Mining Company which consists of 11 units. Even in this mill some amygdaloid is stamped, but the amount is insignificant and the units are not designed for this particular ore.

Nature of Ore

Copper occurs only as native metal with such occasional amounts of oxide and sulphide as to be inexpressible in percentage figures. The metallic particles range from the microscopic to masses of such size as to require special handling at the mines and these large masses are sent direct to the smelter under the local grading of "mine mass." The "mine mass" amounts to about .01 percent of the total copper in the conglomerate, whereas in the amygdaloid it may run as high as 9 percent. Of the product sent to the mill, some in turn is too coarse to enter the stamps without danger to the operating mechanism and this product is hand picked and sent to the smelter under the grade of "mill mass." This particular product constitutes only .2 percent of the total copper in the conglomerate but runs as high as 10 percent of the copper of the amygdaloid. These figures are sufficient to indicate reasons why the treatment of the conglomerate ore must differ very materially from that of the amygdaloid.

The variation between the Kearsarge and Osceola lodes as operated by this company is not as great as between the conglomerate and the amygdaloid. Such variations as are found necessary in the treatment of the amygdaloid is due more to the quality of the ore in point of richness than variations in the size of the copper particles. The Osceola lode will average about 20 lbs. by assay per ton stamped and has a larger percentage of material coarser than jig size than has the Kearsarge. The result of this is that the jig tailings (minus three-sixteenth inch) in the case of the Osceola are not sufficiently high in assay to warrant fine grinding at the present price of copper, whereas with the better quality Kearsarge all jig tailings are profitably reground in ball mills.

Lake Superior metallurgical practice differs from that of any other copper-producing district owing to two unique characteristics of the ore:

1. Native copper is present in all sizes from masses weighing many tons to microscopic sizes, and these particles resist reduction in size when once liberated.

2. The particles of native copper are tougher than the ore and hence are more resistant to abrasion.

Careful analysis of these two properties of the deposit accounts for much of the uniqueness of the metallurgical treatment of Lake Superior ores, a practice that has not been without criticism in the past by metallurgists of other districts, usually without sufficient knowledge of local conditions. It explains why the steam stamp has reigned supreme in the lake copper district for some 50 years in spite of occasional attempts to replace it, although the stamp has made no headway in other camps. It explains why stage crushing has not proved successful even in the days before flotation when such stage crushing was considered an absolute essential of good metallurgical practice in all other districts. It explains the prevalence of jigs and roughing tables in spite of their more recent abandonment in favor of all flotation in many camps. A piece of copper the size of the head or the fist or even of a pea presents rather a firm argument against a diminution in size by any of the known crushing machines.

Historical Development

Some stamps were used on Lake Superior in the sixties, just as soon as the mines began to develop any tonnage. Mechanically the efficiency was low and was so recognized. Later practice consisted of the use of a compound stamp which had a greater efficiency than the simple stamp. In all of the modern plants the exhaust steam from the stamps is used in low or mixed-pressure turbines for generating electricity, thereby obtaining an excellent final mechanical efficiency from the combined units.

Current practice calls for hand picking of large nuggets from the ore, preceding stamping. When a large piece of copper escapes the vigilance of the attendant and gets into the stamp it does no mechanical harm. It remains there, abrading slowly until such time as it may be necessary to open up the stamp in order to change a shoe. There have been times in the past when the presence of these copper nuggets, owing to rich ore, presented a problem. This was solved by the application some 30 years ago of a hydraulic discharge within the mortar. On the amygdaloid, in addition to the original 20 percent of mass, as high as 30 percent of the total copper of some lodes is obtained before the material is of a size of minus three-sixteenths inch at which jigging is practiced.

Before the introduction of the Wilfley table in 1898, the recovery of copper from the fine size or so-called slimes (a separation at about 60 mesh being the local term for slime) was very inefficient. Fortunately the value in these slimes was low because of the non-friable nature of the valuable mineral. The smelters in those days demanded a high grade product so that very little success attended attempts to save the values finer than 60 mesh by means of revolving tables. With the gradual displacement however of the revolving tables by Wilfleys, recovery became greater and there was some incentive to fine grinding. Chilean Mills were universally used for this purpose from about 1905 to 1915 and since that time the standard fine grinding unit of the district has been the Hardinge pebble or ball mill.

Calumet Conglomerate Milling

Of all the mines in the district, only the Calumet & Hecla is operating on conglomerate ore. This lode has been extraordinary in quality, and even after 60 years is the richest ore being mined on Lake Superior. It is well that it has been so for the metallurgical treatment of this material presents difficulties much greater than that of the amygdaloid. This is due not only to the distribution of much of its copper in fine sizes down to the microscopic, but also because of the hardness and toughness of the gangue.

The conglomerate consists chiefly of felsite, feldspar porphyry, and quartz porphyry, with some few amygdaloid boulders. In some parts the lode is made up largely of coarse to fine sand; in other portions it is a pebble conglomerate. The copper occurs chiefly as cementing material around the pebbles. There is some very fine copper within the pebbles, and the sand itself contains copper of microscopic fineness so that complete liberation of values is impossible. The ore has a hardness of 7, is very tough, and there are no fractures once the conglomerate is broken down. Comparative tests on resistance to crushing are difficult to obtain, but such independent work as has been done by outsiders indicates that the Calumet conglomerate resists crushing and particularly fine grinding more than any other known copper ore.

The ore has naturally a high abrasive action corresponding to the resistance to crushing as evidenced by the great wear of stamp shoes in stamping, of pebbles or balls in grinding, impellers and liners in pumping, etc. The chilled iron shoes stamping conglomerate have only one-tenth the life of corresponding shoes stamping Osceola amygdaloid.

The concentration of this conglomerate ore consists principally of four operations which were developed chronologically and are housed in four separate units as follows:

1. Calumet stamp mill containing the stamps, coarse jigs and coarse Wilfley table treatment. This unit was built originally in 1872 and has been added to and remodeled from time to time till 1904.

2. No. 1 regrinding plant containing

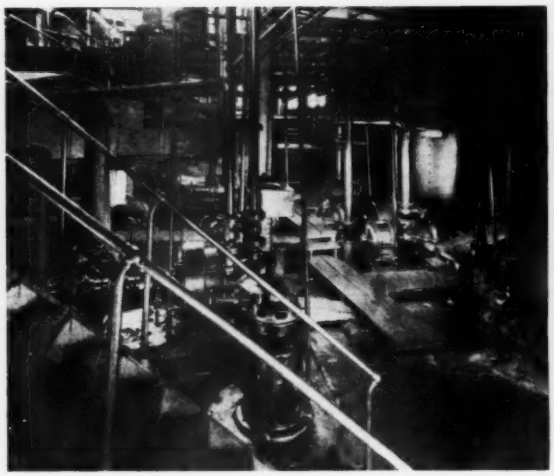


Figure 7. Ammonia solution pumps in leaching plant, Lake Linden

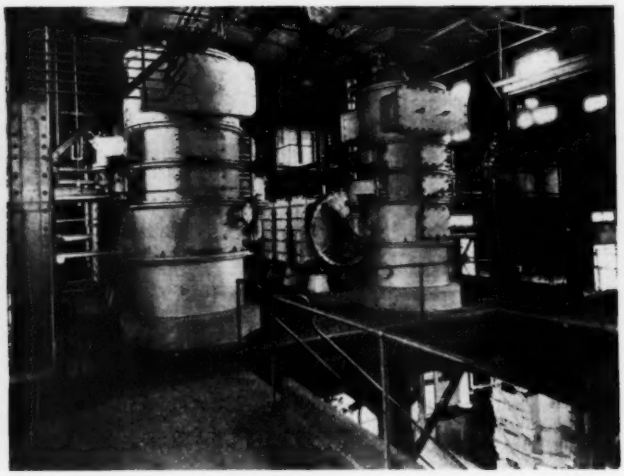


Figure 9. Preheaters in still house, Lake Linden

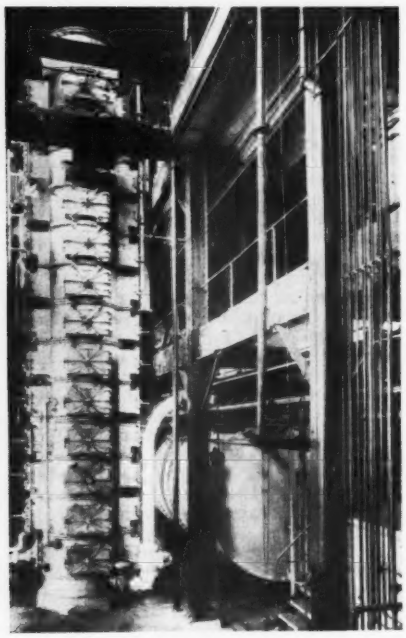


Figure 8. Ammonia still in still house, Lake Linden

Hardinge pebble mills and Wilfley tables for treatment of the reground sand and recovery of the liberated values. This was built as a Chilean mill plant in 1907, which mills were later replaced by Hardinge mills.

3. Leaching plant where ammonia leaching is practiced on the crystalline particles (plus 200 mesh). This plant was constructed in 1915.

4. The flotation plant for the recovery of the values from slimes, erected in 1918.

Figure No. 1 is a flow-sheet of the gravity practice as examplified by one unit of the Calumet mill (of which there are 11 units), one unit of the No. 1 regrinding plant (of which there are 12 units now operating) and sand and slime classification. *Figure No. 2* is a flow-sheet of the leaching plant. (B. P. 9602.)

Crushing and Gravity Concentration

The ore as mined is crushed in the rock house to about 4 in. size by means of Blake crushers and transported to the mill in 40-ton cars. These are dumped into the mill bins which have a live capacity of about 200 tons, being sufficient to keep the stamps running ordinarily throughout the night. Intermediate crushing is entirely by means of Leavitt stamps, which is a single expansion stamp of rather complex design. The stroke of the stamp is 24 in., the weight of new shoe is about 725 lbs., the weight of moving parts about 6,000 lbs., and the horsepower developed is just under 200.

The stamp screens have 3/16 in. round openings punched in a plate 0.11 in. thick. The coarse copper is discharged from within the stamp by means of a Woodbury mortar jig which makes two products, a screen discharge of about 1½ in. nuggets and larger, and a hutch product of about 1 in. size. This jig is actuated by a plunger outside the mortar and is discharged intermittently.

The stamp product, all of it reduced to 3/16 in., is now classified into the so-called slime of about 60 mesh and the coarser sand for jigging and table treatment. For this purpose a Woodbury jig-classifier is used which makes four products:

1. Slimes at about 60 mesh.
2. Hutch product for table treatment.
3. Coarse copper concentrates.
4. Coarse and fine sand tailing.

This Woodbury classifier was developed at the Calumet & Hecla and is very effective for the purpose, although it is now being displaced to a great extent in the district by the Dorr classifier which makes only two products but eliminates dilution of the slime.

There are two lines of classifiers and jigs per stamp. (*Figure 3.*) The hutch product of the jigs is treated on Wilfley tables and the tailings of these Wilfleys along with the tailings of the jig go to the No. 1 regrinding plant for finer grinding. The slime separated out on the original slime classifier is thickened in 25-ft. diameter three-tray Dorr thickeners and treated by flotation.

The copper recovery in the original stamp mill is between 75 and 80 percent of the value of the ore, the rest of the recovery taking place in the so-called retreatment plants consisting of fine grinding, leaching and flotation. The concentrates are graded chiefly by size as follows:

Grade	Assay percent	Percent of Total copper
No. 0 Grade (⅝-inch)..	91.50	3.75
No. 1 Grade (+10 mesh)	89.00	40.75
No. 2 Grade (—10 mesh)	57.00	55.50

These figures are for stamp mill concentrates only. Including fine grinding, leaching and flotation recoveries, figures are as follows:

Grade	Assay percent	Percent of Total copper
No. 0 Grade (⅝-inch)..	91.50	2.75
No. 1 Grade (+10 mesh)	89.00	30.75
No. 2 Grade (—10 mesh)	55.00	47.75
Flotation (—100 mesh).	35.00	9.50
Leaching (oxide).....	82.00	9.25
	61.00	100.00

Fine Grinding

The fine grinding units consisting of 8 ft. by 72 in. Hardinge mills, are run at a speed of 24 r. p. m., and are driven in units of three by 250 hp. motors. There are 24 of these mills in the No. 1 regrinding plant (*Figure 4*) with only half of them being operated at present. Each mill has capacity of about 110 tons per 24 hours, requires 90 hp. and is run open circuit at a dilution of about 25 percent solids. The mills are lined with old steel rails embedded in neat cement. Danish pebbles preferably 4 in. in size are used as the grinding medium. The pebble consumption is about 5 lbs. per ton of sand ground and as the pebbles cost about ¾ cent per lb. delivered at the plant, the total cost of grinding for pebbles is 4 cents per ton of sand. Steel balls have been tried and abandoned because of excessive cost, as the wear per ton of sand ground is almost as great with steel as with pebbles. This arises from the hardness of the ore and does not hold true for amygdaloids.

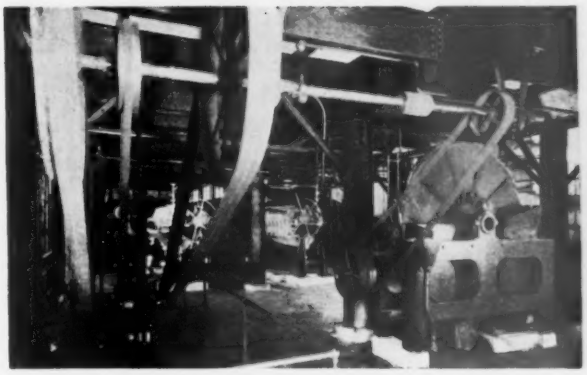


Figure 10. Vacuum and pressure filters in still house, Lake Linden

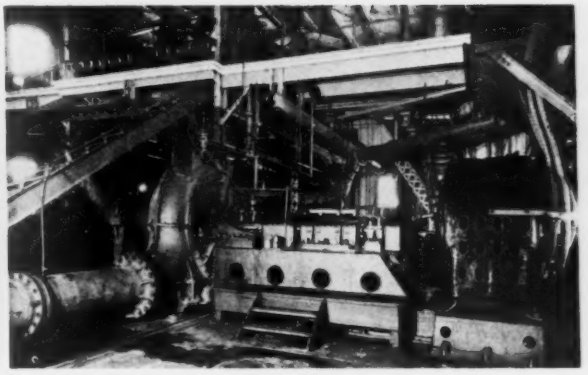


Figure 11. Twenty-inch suction pump in dredge, Lake Linden

The cost of this grinding per ton for the year 1930 is as follows:

General Expense	1.4c
Conveying and distribution	.5c
Grinding	12.2c
Attendance	.9c
Power	7.2c
Pebbles	3.1c
Lining	.7c
Other	.3c
Washing	1.9c
Total	16.0c

Following this grinding and table concentration all the product is classified into sands for ammonia leaching and slimes for flotation. (*Figure 5.*) This separation is roughly at 200 mesh although there is some 15 percent of minus 200 mesh material that goes to leaching and some 5 to 10 percent of plus 200 mesh that goes to flotation. It is quite possible to float copper of a much coarser size than this, but because of the enclosed copper in material even as small as minus 100 mesh the recovery by means of flotation is low at this size. Accordingly on conglomerate only the very fine sizes are treated by flotation, whereas with the amygdaloid flotation at 35 mesh is practiced.

The slimes from the fine grinding units are thickened in three-tray Dorr thickeners 40 ft. in diameter. After thickening, the products from the original stamp mill and that from the regrinding plant unit are combined in treatment by flotation. This flotation is described in a separate article in this same issue of THE MINING CONGRESS JOURNAL.

LEACHING

Sands are treated by means of ammonia leaching. This operation has been frequently described in detail in the technical press* and will be given but briefly here.

This process was developed at the Calumet & Hecla independently but concurrently with a similar development on oxidized ores by the Kennicott Copper Company. It has been used in a modified form also by the Bwana M'Kubwa Copper Company in Northern Rhodesia. Both the plants in Alaska and that in Rhodesia are now shut down so that this operation of the Calumet & Hecla represents the only copper ammonia leaching plant at present operated.

The equipment for dissolving copper from the sands consists primarily of 16 steel leaching tanks 54 ft. in diameter by 12 ft. high in two rows of eight each (*Figure 6.*), and 25 solution storage tanks with the necessary pumps (*Figure 7*) and piping for circulating solutions. In addition to these there are auxiliary devices such as oxydizing towers and condensing units. Regenerating the solvent and recovering the dissolved copper is effected by distillation.

The sand for the leaching tanks is all minus 28 mesh. All copper that can possibly be saved by gravity concentration has been extracted, and the remaining copper is chiefly attached to or included in the grains of sand. The average sizing will show 15 to 20 percent of minus 200-mesh material of which only a small portion is colloidal. The major portion of this colloidal material remaining after classification escapes from the main body of sand in the overflow of the leaching tanks during the filling operation.

The solvent employed is cupric ammonium carbonate. After distillation the return to the leaching cycle consists of ammonium carbonate, but losses of reagent during the process are made up by aqua ammonia which is carbonated in the plant in the same towers in which the solution is oxidized from the cuprous to the cupric state.

The chemistry of the process is simple. As native copper is the only valuable mineral present in the ore, advantage is taken of the two valences of copper in water solution to effect its oxidization and subsequent solution in the cuprous form. The first reaction is between native copper and cupric ammonium carbonate in an excess of ammonium carbonate to yield cuprous ammonium carbonate, weight for weight of copper. To use this copper ammonium carbonate as a new leaching solution it must be regenerated to the cupric condition by oxidizing it with air. This reaction between cuprous carbonate and oxygen takes place in the presence of ammonium carbonate and yields cupric ammonium carbonate which is now ready for the next leaching cycle.

After the leaching solution is partly or entirely saturated with copper by passing it through the ore, an amount equivalent to the copper dissolved from the sand is removed from the leaching cycle and is distilled to yield copper oxide, with the recovery of the ammonia and carbon dioxide as ammonium carbonate. This leaching cycle theoretically results in no loss of solvent, the only actual chemical consumed being the oxygen of the air which appears in the copper oxide in the final product.

The leaching tanks are in two rows. A crane travels over each row of tanks for handling removable tank covers, sand distributors, sand levelers, flushers, and other auxiliaries. As the tanks must be covered during leaching to prevent loss of ammonia by volatilization and to make it possible to live in the plant, all distributing and flushing apparatus must be removed instead of fixed to the building structure as it might be if open tanks could be used. The tank covers are of steel plate with top trusses which are supported on an encircling angle iron around the tank wall. A seal between the cover and the tank is made by a channel-iron on the cover projecting into an annular launder on the tank, which launder acts as an overflow carrier during the sand-filling stage and is filled with water during the leaching stage. This seal prevents the escape of ammonia around the edges of the cover and is the only joint necessary either during the leaching or the steam wash.

For filling the tanks a portable distributor of the Betters and Mein type is used. It is supported on the central shaft of the tank and revolves by its own reactance. The sand is carried throughout the length of the plant in a central launder, and connections are made from this central launder to the distributor by means of a portable launder. Gates in the central launder control the flow so that the sand is led consecutively from tank to tank. The alternating tanks are on either side of the main central launder, and with two sets of portable launders and distributors there is no delay in filling while shifting from a full tank to an empty one.

The sand in the tank is supported on a canvas filter which is stretched over cocoa matting, which cocoa matting in turn is supported on a steel grating of about ⅝ in. mesh. This steel grating in turn is carried on a steel grid resting on the tank bottom permitting free circulation of the solvent beneath the filter. The canvas has a life of seven to eight months and the cocoa mattings are changed with every second canvas.

After the tank is filled with sand the excess water is drained off, the tank is leveled by means of vertically directed water jets, the cover is put on, and the leaching solution is run upon the sand from the radial solution piping. The

* Eng. and Min. Journal, July 14, 1917. Trans. A. I. M. M. E., Feb., 1924. I. C. 6364, Department of Commerce.

Figure 12. Shore plant classifying building, Lake Linden.

sewer valve is opened during this stage of the operation and the leach is run on as quickly as possible without overflowing, so that the water in the interstices of the sand is displaced downward by the on-flowing leach. When ammonia begins to show in the affluent solution the sewer valve is closed and the pregnant solutions are run into their proper effluent pipe line. The rate of flow of the leach is then reduced to the predetermined figure of about 34 cubic meters per hour for a total quantity of 650 cubic meters.

After the leaching solution has been led on to the sand, it is drained down for about an hour and 170 cubic meters of wash added. This wash is high in ammonia but low in copper. It has a slight leaching effect but its main object is to displace the rich copper-bearing leach. After the first wash there is another period of drainage and 50 cubic meters of strong ammonia distillate is used. The function of this distillate or second wash is to remove or wash out the copper which is still adsorbed in the sand. After this distillate wash some 70 cubic meters of water is run upon the tank, it is drained for about five hours and then steamed to remove the last traces of ammonia. The steam is applied above the sand through a special cover, and suction applied from the bottom pulls the steam through the entire body of sand thus heating it up and carrying to a condenser the remaining ammonia.

While on-going solutions have been applied as above, the effluent solutions have been drained off as follows: The first 15 to 30 cubic meters is of varying composition owing to dilution and may contain a certain amount of calcium and magnesium carbonate in suspension derived from reaction with corresponding chlorides in the lake water. It is run back to the leach storage tanks and then, dependent upon the quality of the sand, a quantity of rich solution approximating 150 cubic meters in volume is drawn off for distillation. This volume must contain an amount of copper equal to the quantity extracted from the sand, and is a variable regulated by the quality of that sand. Following this, 650 cubic meters of leach is drawn off which regenerates that solution, and after this in turn the wash is drained off approximating over a series of tanks the volume added in the previous cycles.

This wash completes the cycle so far as the solution is concerned. The spent ore is now flushed out and the tank is ready for the next cycle. The complete operation requires about 52 hours.

Distillation

Coincident with the dissolving of the copper values from the sand, the rich solution is distilled to yield its copper oxide. This distillation takes place in stills (*Figures 8* and *9*) furnished by the Semet-Solvay Company and are the same in principle though not in detail of design as the ordinary ammonia still used in by-product coke plants. Appropriate means must be taken to recover the suspended copper oxide from the spent liquors which is accomplished by means of American and Sweetland filters. (*Figure 10.*) The ammonia and carbon dioxide gases are condensed and returned to the leaching cycle as ammonium carbonate.

The ammonia loss per ton of sand treated is just under ½ lb. NH_3. The distribution of the cost per ton of sand treated for the year 1930 is as follows:

General Expense	2.6c
Conveying and classification	2.8c
Leaching:	
Ammonia	3.5c
Steam	3.9c
Other	2.2c
Distillation:	
Steam	2.9c
Other	4.1c
Total	22.0c

Calumet conglomerate ore is one of the few ores mined in this country that requires both leaching and flotation for its most economical treatment. It is quite possible that if the leaching process had not been invented a satisfactory metallurgical recovery could be made by grinding the ore to a fineness sufficient to liberate values for recovery by flotation. This would require, however, power that has not been available in the past and would be at a figure in excess of present operating costs.

For the year 1930 complete milling costs of this ore including stamps or coarse crushing, fine grinding by means of Hardinge mills, leaching of the sands and flotation of the slimes are as follows:

Primary grinding (stamps)	19.0c
Gravity concentration (wash)	5.9c
Secondary grinding (pebble mills)	8.8c
Flotation	3.6c
Leaching	10.6c
Tailing disposal	1.5c
Superintendence, sampling, etc.	3.5c
Total	52.9c

Lake Linden Reclamation Plants

The Lake Linden plant has recently been described in I. C. 6357 Department of Commerce, to which the interested reader is referred for such details as may not be given in this shorter article.

The various units are located along the shores of Torch Lake at a slightly lower level than the concentrator itself, and the treatment of fine material by leaching and flotation is in common with that of the corresponding product from the mine. This plant has been operating for some 15 years and the sands available are more than half exhausted.

It was recognized at least 30 years ago that there were values in the tailings that could be recovered at some time in the future, and every step of advance in metallurgy made this possibility more certain. The introduction of fine grinding machines was sufficient to warrant a beginning of operations and work was begun in 1913 with only recovery by gravity anticipated. The leaching process fortunately was developed shortly thereafter, and this in turn was followed by the application of flotation to native copper so that instead of the original anticipated recovery of 35 to 40 percent from grinding alone, there has been realized an actual recovery of approximately 90 percent of the values contained in the tailings.

There are five main operations to this metallurgical process separately housed as follows:

1. Dredge for picking up material from the lake and conveying it through a pontoon line to a central point on shore.
2. Shore pumping plant and classifying house where the material is classified into coarse sand requiring further grinding and fine sand ready for leaching and flotation.
3. Regrinding plant where material is ground to minus 35 mesh and liberated values recovered.
4. Leaching plant as described above.
5. Flotation plant as described in a separate article in this same issue.

The dredge adopted was of the hydraulic type and was purchased from the Bucyrus Company of South Milwaukee. It is a steel hull dredge 56 ft. wide and 110 ft. long. The dredge pump (*Figure 11*) has a 20 in. diameter inlet and outlet, with impeller 55 in. in diameter and is driven by a 1,250 hp. motor. The suction mouth is equipped with nozzles which discharge water under 150 lbs. pressure and keep the sand in agitation in front of the suction ladder. This has proven entirely satisfactory for this class of material, being simpler than the rotary cutter of the ordinary type of suction dredge.

The suction ladder is 141 ft. long and permits of dredging to a depth of 110 ft. The dredge is not self-propelling but is operated by swinging lines fastened to anchors in the water and to dead-men along the shore. These lines are operated by electrically driven drum-winches, the electric wires being carried into the dredge on towers attached to the pontoons which float the discharge pipes.

The pontoon pipe discharges at a fixed point on the shore onto a stationary screen 16 ft. by 20 ft. in size with openings 1 in. in diameter. This is so located that the sand runs from the screen into a pond or reservoir controlled as to discharge by a revolving bridge which carries the suction pipe of the shore plant pump. (*Figure 12.*)

The dredge has a rated capacity of 10,000 cubic yards per day. No effort is made to synchronize the operations of the dredge with that of the shore plant. The dredge operation is necessarily intermittent and the dilution of the material pumped varies from minute to minute. The shore plant pump on the other hand with fixed length suction and discharge line operates under uniform conditions which is naturally essential to the operation of the treatment plants.

The shore plant is really a stationary dredge. It is built upon a concrete dock

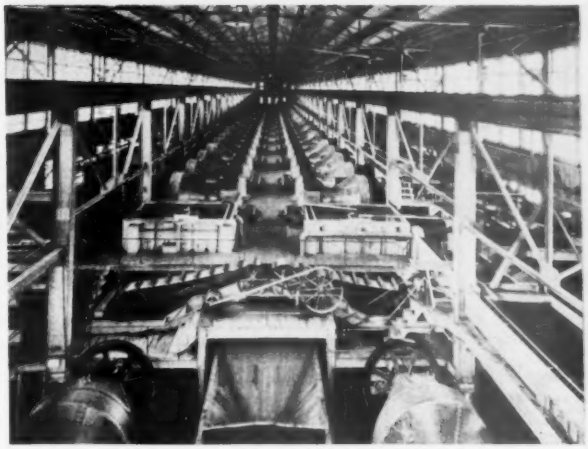


Figure 13. No. 2 regrinding plant, Lake Linden.

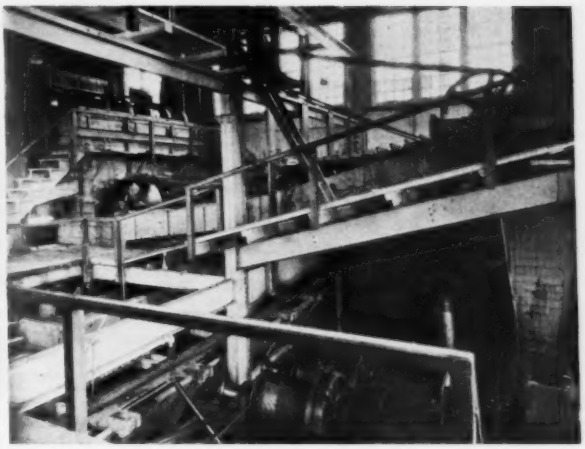


Figure 14. Shore plant classifying building, Tamarack reclamation plant.

constructed by driving piles through the sand down into the original lake bottom and upon these piles putting a cap of concrete 3 ft. 6 in. thick. In the shore plant are a 12-in. Morris centrifugal pump for elevation of the sand, screens for removing rubbish, drag belts for classification into coarse and fine and with the necessary equipment for pumping fine sands into the leaching plant classification system and a belt conveyor for conveying the coarser sand to the top of the regrinding plant. (*Figure 13.*)

The next step in the operation is the regrinding of the coarser sands. The regrinding plant building was one of the first built after the successful development of the Hardinge mills and contains 64 of these mills 8 ft. in diameter by 18 in. cylindrical length. The large number of mills of this size are more spectacular than efficient, but it has not seemed advisable to replace the present equipment with larger and more economical units. This regrinding plant has a capacity of about 3,000 tons per 24 hours. Grinding is in open circuit and pebbles are used for the grinding medium. This is very economical in operating cost and tests with ball mills have shown an increase in cost too great to offset the advantages of increased capacity.

The total cost of operation of the reclamation plant for the year 1930 based on tonnage dredged follows. These costs include leaching and flotation, operations sufficiently described or noted in previous paragraphs.

	Cost per ton
General administration, mine and mill	5.1c
Dredge and pontoons	7.5c
Shore plant and belt conveyor	2.9c
Regrinding	17.6c
Leaching	16.3c
Flotation	1.9c
Miscellaneous	2.5c
Total	53.8c

These costs are somewhat higher than average because the plant was operated only five days per week until November 15, at which date it was shut down completely and is not operating at the time of this writing.

Tamarack Reclamation Plant

The plant as described above is the reclamation plant treating the conglomerate sands of the original Calumet & Hecla mine. It represents a development extending over a construction period of possibly five years. Its operation was so successful that treatment of the conglomerate sands of the Tamarack Mining Company was indicated and a plant was built which started operation in 1925. Instead of units separately housed as in Lake Linden, the Tamarack plant has its three treatment operations of regrinding, leaching and flotation practically under one roof. Instead of Hardinge mills 8 ft. in diameter by 18 in. cylindrical length, the 8 ft. mills are 72 in. in length and have about three times the capacity of the smaller mill with a better mechanical efficiency. The entire plant has a capacity approximately two-thirds that of the Lake Linden plant.

The dredge and shore plant of the Tamarack do not differ materially from that at the older plant—in fact the dredge now being used at Tamarack was the one originally purchased for Lake Linden. Correspondingly, pumps and drag classifiers (*Figure 14*) are similar in operation in both plants and the coarse material is likewise conveyed by means of a belt conveyor to the top of the regrinding plant. (*Figure 15.*) There are 18 of these 8-ft. mills and the coarse sand after grinding is treated on Wilfley tables. The table tailings are classified into coarse sand for leaching and fine sand for flotation.

The leaching plant (*Figure 16*) consists essentially of six tanks, 54 ft. in diameter by 12 ft. high, with the necessary storage facilities for solutions and circulating pumps for the conveying of the solutions. There is a single dis-

Figure 15. Regrinding plant, Tamarack reclamation plant.

Figure 16. Ammonia leaching tanks, Tamarack reclamation plant.

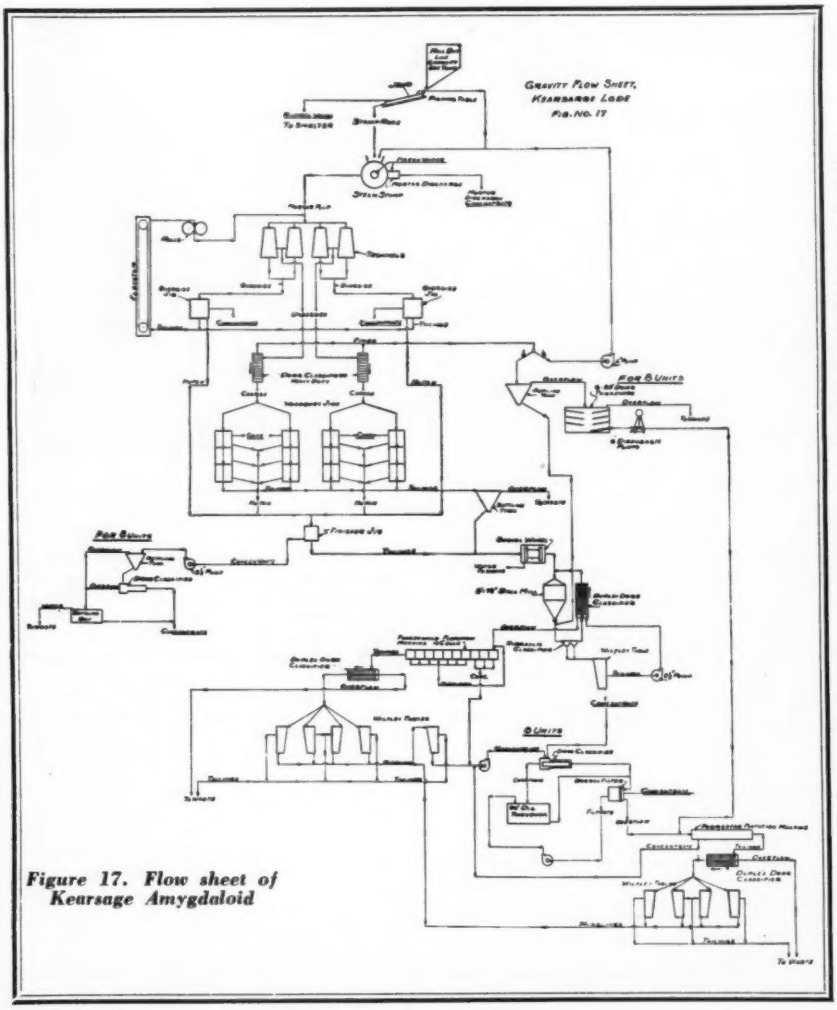


Figure 17. Flow sheet of Kearsage Amygdaloid

tillation unit in the leaching bay and one crane suffices for all purposes. The flotation equipment consists of four Dorr thickeners 40 ft. in diameter, four compartments each, and the thickened product is treated on a 16-cell minerals separation flotation machine.

The entire plant is very compact but costs are slightly higher than at Lake Linden owing to the lower capacity, and also to the fact that at Lake Linden a large part of the overhead is shared by the operation of treating the mine rock. The following figures will show the costs at the Tamarack plant for the year 1930. It was operating on reduced schedule to November 15, at which time all operations were suspended pending recovery in the demand for copper.

General administration, mine and mill	9.2c
Dredge and pontoons	8.3c
Shore plant and belt conveyor	3.9c
Grinding	11.6c
Leaching	16.5c
Flotation	2.2c
Miscellaneous	7.3c
Total	59.0c

Amygdaloid Practice

There have been no new mills built in the Lake Superior copper district for the treatment of amygdaloid ore in the last 20 years. There has been a decided change in the flow sheet in the last few years owing to the successful adaptation of flotation to relatively coarse material, but the stamps and coarse grinding stand very much as they did even 30 years ago. The great impetus to the development of the Lake Superior mines occurred in the copper boom of 1898 and amygdaloid crushing practice at least has been fairly well stabilized since about that time.

Owing to the very low copper tenor of the amygdaloid mines, all effort was for many years directed towards capacity of the stamping units and a low cost of metallurgical treatment. This was not done entirely at the sacrifice of metallurgical efficiency because fine grinding at that time was very much in its infancy and there were no practical means of saving liberated copper in the fine sizes. The capacity of the stamps was gradually increased by means of the introduction of ⅝-in. round openings in stamp mortar-screens followed by trommelling through a 3/16-in. screen. The oversize of the trommels was returned first in development to the stamps and later to high speed rolls. This is present practice and results in a capacity at the Ahmeek plant, about to be described, of over 800 tons per stamp unit per 24 hours. This is the maximum capacity unit on Lake Superior at the present time and is small compared to corresponding units in western practice.

The capacity of the mills is relatively small, the Ahmeek mill with its 6,500 tons daily capacity being the largest in the district. The small unit is not without its value so far as mining operations are concerned, because from the nature of the deposit there is no underground sampling done, and the mining captains get their best and only accurate knowledge of the quality of the ore from the stamp mill returns. With many of the shafts having a daily capacity only slightly in excess of that of a stamp unit, there is a correlation possible between these two operations, and it becomes necessary to keep the concentrates of the ore from the various shafts separate so that the mills partake something of the nature of custom units.

Where the shafts are on the same lode, in spite of the variation in copper content, the metallurgical process is uniform, but where the ore varies not only in quality but also in the nature of the distribution of the values, it becomes necessary to modify the metallurgy dependent upon the quality of the ore. So far this has been applied only to a variation in the extent of the fine grinding. In the case of the Osceola amygdaloid at the Ahmeek mill, a middling product is drawn off from the jigs to the extent of about 15 to 20 percent of total stamp capacity and this material is ground in ball mills to minus 28 mesh for flotation. In the case of the Kearsarge lode all of the coarse material (jig tailings) is ground to this size.

A flow sheet of the Kearsarge lode operation is shown in *Figure 17*.

Ahmeek Mill

The stamps at the Ahmeek mill are compound stamps of the Nordberg design (*Figure 18*). The high pressure cylinder is 16½ in. in diameter and the initial steam pressure is 150 lbs. The exhaust from this cylinder goes to a receiver and from this to the low pressure cylinder 32 in. in diameter, operating at a pressure of 38 lbs. These stamps are non-condensing and the exhaust steam at a pressure of 16 lbs. absolute goes to a low pressure turbine, thus giving a final mechanical economy that puts the efficiency of the combined unit well into the class of an electrically operated crushing device.

The stamp mortar discharges only at front and back, whereas most of the stamp mortars of the district are either four-way discharge or in some cases circular. The two-way discharge is ample to give sufficient screening capacity for the stamp product and is much more economical in upkeep. These stamp screens have 5/8 in. opening and the material goes first from these stamps to four trommels with 3/16 in. punched openings. The oversize of the trommels goes to a bull-jig which makes a 5/8 in. concentrate assaying well over 90 percent in copper. The tailings of the bull-jig go to a 36-in. by 16-in. high-speed Nordberg roll and thence to the original stamp trommels, the bull-jigs and rolls being in closed circuit with the stamp.

The material now finer than 3/16 in. in size is classified by means of two Dorr classifiers 3 ft. wide by 18 ft. 4

in. in length. The slimes from one of these Dorr classifiers (50 percent of total capacity) is returned to the stamp, replacing a corresponding volume of fresh water in order to save dilution. The slimes from the other classifier is settled out in a small settling tank, the plug product of which joins the ball-mill product for flotation, and the overflow of the tank is finally settled and thickened in a series of Dorr three-tray thickeners.

The Dorr classifier product is treated on Woodbury jigs for the removal of coarse concentrates and the entire tailings of these jigs ground in an 8 ft. by 72 in. ball mill. This ball mill has a capacity of from 450 to 550 tons per 24 hours, which capacity for coarse sand determines the original capacity of the stamp. Depending somewhat upon the nature of the ore approximately two-thirds of the original tonnage requires regrinding. The ball mill is in closed circuit with a heavy-duty duplex Dorr classifier 8 ft. by 25 ft. in size. The circulating load is about 300 percent and the crushing which varies somewhat with the load is held as nearly as possible all to pass the 28 mesh screen.

Closed circuit grinding has only recently been adopted in Lake Superior practice. Because of the nature of the ore, particularly the non-friability of the native copper, it was appreciated that it would be difficult to remove the liberated copper from the circuit. In early experiments along these lines, the copper built up until the value of the circulating load was many times that of the original feed and reached an equilibrium only when abrasion, which was very slow, balanced the liberated coarse copper. This made for very inefficient mechanical work and resulted in the production of large quantities of fine, almost floured copper, which was lost in the tailings of the tables treating the ground product. With the adoption of the flotation process for this product, the disadvantages of the abrasion was eliminated, but not the presence of a large quantity of liberated copper remaining in the circuit. It was necessary in some way to remove this material and in the flow sheet as adopted at the Ahmeek mill the product of the Hardinge mill is subjected to a hydraulic classification and the plug product from this classifier is treated on a Wilfley table, the tailings of which are returned to the ball mill. The closed circuit embraces not only the Dorr classifier but also the Wilfley table operating on a selected portion of the circulating load. This has proven very effective in removing the liberated values and has eliminated the last objection to closed-circuit work on ores containing native copper.

The crushing is at 70 percent solids. After crushing, with the plug product from the slime settling tank added, the dilution preliminary to classification is 60 percent solids. This material is then treated by flotation.

The flow sheet is really very simple. It consists essentially in grinding to minus 3/16 in. by stamps and rolls, classifying into sand and slimes, jigging the sand to separate out liberated copper, regrinding all jig tailings by means of the closed circuit ball-mill, and final flotation of the entire product of the unit.

The following grades of concentrates are made:

1. "Mill Mass," which consists of large pieces of extremely rich rock hand-picked before going to the stamps and which are sent direct to the smelter at about 60 percent copper.

2. The copper discharge of the mortar, consisting of nuggets ranging from 1 in. up to 3 or 4 in. and assaying 95 percent in copper.

3. Bull-jig concentrates, being material approximately 5/8 in. in size, and assaying from 92 to 95 percent in copper.

4. Woodbury jig discharge and hutch concentrates averaging 85 percent in copper.

5. Flotation concentrates averaging 60 percent in copper.

The first four classes of concentrates produced are sufficiently coarse so that they drain very rapidly and are ready for shipment to the smelter without any auxiliary treatment. There is a small quantity of copper produced on so-called finishing jigs or tables which is about 20 mesh in size and which is dewatered by means of a drag classifier before shipment. The flotation concentrates require special treatment and after a preliminary dewatering by means of a drag belt are filtered in a Dorrco filter, the water contained being reduced to 11 percent before shipment.

The costs of operation according to this new flow sheet are not sufficiently definite at this time to give in detail. A new power plant has just recently been installed, and lessened power costs will materially reduce final operating figures. Mine operations are also intermittent owing to the present unhealthy condition of the copper market, adding to the difficulty of obtaining representative figures. For the year 1930, operating without complete regrinding of jig tailings, the milling costs were 24.2c per ton.

The metallurgical extraction is well over 90 percent. For a given lode it varies directly with the quality of the ore. The Kearsarge lode has been yielding about 28 lbs. per ton and on ore of this quality, with fine grinding of all jig tailings, the final recovery is over 95 percent.

On Osceola ore there is not the incentive to high metallurgical recovery at added cost of treatment because of its low copper content. For a given grade, Osceola lode material will yield a higher percentage extraction than Kearsarge, because the distribution of the copper is in a coarser state. With ore assaying from 18 to 20 lbs. per ton, a jig tailing of 2 to 2½ lbs. per ton by assay can be obtained by drawing off only a relatively small percentage of the total sand as middling. At 10c per lb. copper, which is the selling price at the time this article is being written, the cost of recovering copper from jig tailings of this quality would just about equal the revenue to be obtained therefrom. It would probably require a market price of about 14c per lb. of copper to justify the necessary capital expenditure for grinding all Osceola lode sand to a size suitable for flotation.

As operated during the year 1930, the Ahmeek mill treated 1,193,704 tons of Kearsarge and 571,884 tons of Osceola ore and no effort was made to keep the costs separate on these two lodes. The table given below will show the most important data for this mill as a whole.

YEAR 1930

Ore stamped	1,765,588 tons
Stamping rate per 24 hours	788 tons
Tons ore stamped per lb. shoe worn	26.03
Tons ore stamped per ton coal consumed	48.10
Tons per man per day	38.45

Costs per ton stamped:	
General expense	.020
Stamps	.120
Grinding and gravity concentration	.069
Flotation	.024
Tailing disposal	.009
Total	.242

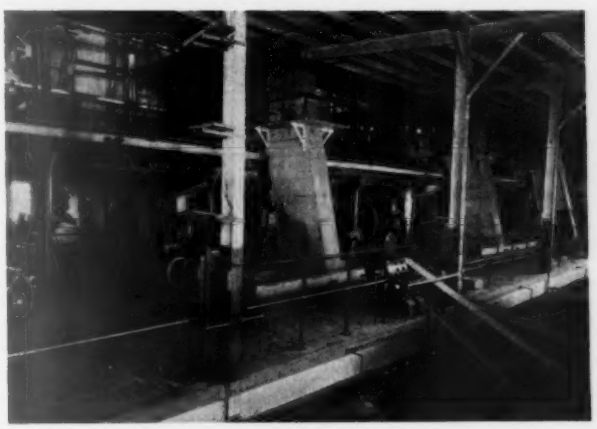


Figure 18. Steam stamps and auxiliaries, Ahmeek mill.

Figure 1. 40 ft. thickeners in north flotation plant, Lake Linden.

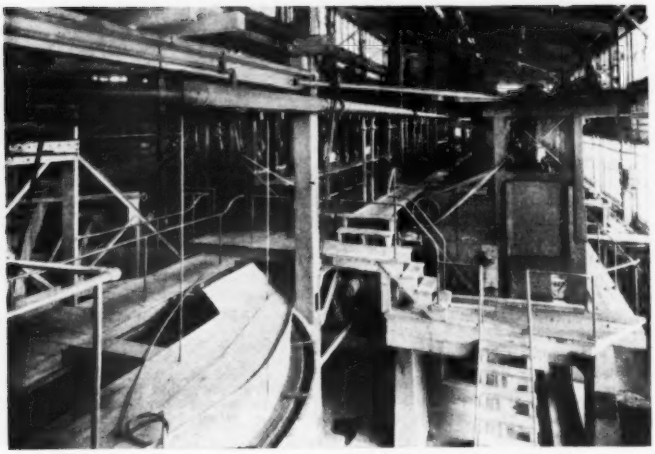


Figure 2. Standard minerals separation flotation machines, north flotation plant, Lake Linden.

Figure 4. Fahrenwald flotation machines, Ahmeek mill.

FLOTATION

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FLOTATION was introduced at the Calumet & Hecla in 1918, at which time the first plant was put in operation to treat the fines from the stamps in both the Hecla and Calumet mills. The following year the North Flotation plant was completed and began handling the slimes from the reground lake sand together with that from the mills. Five years later two more flotation machines were added to those originally in this plant and the installation treating the primary slimes was then shut down.

The Tamarack reclamation plant was put in operation in 1925 to treat the old Tamarack sand. This plant is equipped with four 40-ft. diameter three-tray Dorr thickeners and two flotation machines to handle the slimes. Xanthate was adopted about this time in place of the coal tar oils theretofore used.

Three years later the Fahrenwald flotation machine was tried out and adopted for treating the amygdaloid sands which were too coarse for the old standard Minerals Separation machine to keep in suspension. Fahrenwald machines were installed at the Ahmeek, Isle Royale, and Lake Milling Company mills to treat the fines from the stamp together with the reground jig middling. Last year at the Ahmeek mill the practice of regrinding and floating the entire stamp product was begun.

Conglomerate Flotation Practice

The ores treated in the Calumet & Hecla stamp mills are of two very different types, (1) conglomerate and (2) amygdaloid. The former comes from the Calumet conglomerate and the latter from the Kearsarge and Osceola amygdaloid lodes. The conglomerate ore is noted for its hardness and carries a large part of its copper in such finely disseminated form that grinding through 200 mesh does not liberate it very thoroughly from the gangue, while on the amygdaloid, crushing through 48 mesh is sufficient to give a satisfactory extraction. Curves plated from the screen analyses of flotation tailings from these ores show this clearly.

As a consequence the conglomerate tailings are separated into plus 200 and minus 200 mesh products and only the later is floated, the coarser sand being leached with ammonia.

The north flotation plant handles the conglomerate slimes. The feed is derived mainly from two sources, (1) primary slime from the stamps, (2) secondary slime from the pebble mills in the regrinding plants. Most of the latter comes from the reclaimed sand from Torch Lake. About 1,000 tons per 24 hours of primary slime is treated and 1,400 tons of reground sand together with a highly variable amount of reclaimed slime from the lake. The pri-

* Metallurgist.

PRACTICE

Calumet & Hecla

Robert M. Haskell*

mary slime when treated by itself gives a decidedly higher tailing and richer concentrate than the reground sand (—200 mesh), but treating the combined product has given a better final result than handling them separately, partly because the feed is more steady and uniform in quality as well as in quantity.

The secondary slime which is derived from the leaching plant classification system comes into the plant at a density of approximately 2 percent solids and is divided between twelve 40-ft. diameter, three-tray Dorr thickeners, of both the open and connected types. (*Figure 1*). The thickened underflow at 25 percent solids is plugged off into an 8 in. direct connected Morris sand pump from the four thickeners nearest it and by means of 4 in. quadruplex diaphragm pumps from the others. To avoid the use of additional reagent feeders and obtain maximum conditioning, Xanthate, lime and pine oil are added at the feed pump. In addition to this feed, the slime from each head in the stamp mill is thickened in a 25 ft. diameter three-tray tank and the combined slime pumped over to the 8 in. feed pump which elevates the pulp to a distributor located between the flotation machines and is split between four of them. There are a total of six 16-cell, 24-in. standard Minerals Separation machines of the splash type, two usually being held as spares. (*Figure 2*). The feed enters the fourth cell, which is used for mixing only. From the remainder of the machine a rough concentrate is skimmed off which is elevated in a bucket elevator to the head of the machine and cleaned in the first three cells. This concentrate from all four machines is combined in another elevator and sent to the latter part of that machine nearest the concentrate thickener, for recleaning. This portion of the machine is blanked off from the rest and consists of five cells. The final concentrate flows by gravity to a 25-ft. diameter concentrate thickener. Two pneumatic machines of the Inspiration type, each consisting of seven cells 3 ft. by 4 ft. 6 in. in size, act as scavengers on the tailing from the Minerals Separation machines and make a low grade middling which returns to the feed pump. This operation lowers the tailings about .01 percent copper, although with the old coal tar reagents this saving was twice as great. The tailing flows to a second 8 in. pump which elevates it to the tailing bank in Torch Lake. This flow sheet is shown in figure 3. (B. P. 9602).

The underflow from the concentrate thickener at 60 percent solids is pumped by means of a 2 in. pressure diaphragm pump to an 8 ft. by 8 ft. Oliver filter. The filter cake carrying 13 percent moisture drops through a chute into a 50-ton hopper-bottom concentrate-car for shipment to the smelter.

The summary of operations at the North Flotation plant for the year 1930 follows:

Tons treated	625,760 tons
Copper recovered	5,427,000 lbs.
Assay feed	.527
Assay tailing	.105
Assay concentrate	35.55
Recovery	80.3

Costs

General		1.2c
Pumping and thickening		1.9c
Flotation:		
Attendance	.6c	
Power	1.3c	
Reagents	1.8c	
Repairs	.6c	4.3c
Royalty & Miscellaneous		1.1c
Total		8.5c

Reagents

In the beginning a crude pyridine oil obtained as a by-product from the manufacture of ammonia from certain by-product coke oven plants proved to be the best collector. A few gas-plant coal-tars and creosotes were satisfactory, more especially as stiffeners for the pyridine. Wood creosote together with some pine oil were used as frothers. The recovery was about 70 percent and grade of concentrate 25 to 30 percent copper. Xanthate increased 10 to 15 percent over previous results and the grade of concentrate to 35 to 40 percent copper. The reagent consumption is as follows:

Sodium xanthate	.05 lbs. per ton
Pine oil	.15 lbs. per ton
Lime	.30 lbs. per ton

The pine oil used is a mixture of 75 percent G. N. S. No. 5 and 25 percent Cleveland Cliffs No. 2 wood creosote at the feed pump. A. T. & T. No. 11, a destructively distilled pine oil, is used in place of wood creosote in the mixture for the drip cans on the machines. The drip cans are allowed to stand a day or so before use, which allows any sediment to settle out, thus preventing choke-up troubles.

The ores of this district are all more or less alkaline due to the presence of considerable lime and no sulfides. Even the lake water has a pH content of 7½ and the water in the flotation feed is usually about 8, so little alkali is needed. As the lime drops the iron oxide, which the wood creosote tends to float, and also decreases the pine oil required, a little of it is still used, although more than half of the total is added to the thickeners to aid in settling the slime. The lime is slacked in boiling water at 4 to 1 in an altered form of Pachuca tank with a coarse screen over the bottom, and then diluted to 10 to 1 before use. This gives a very high percentage of lime in soluble form. Diaphragm pumps are used for lime feeders.

Of all the different xanthates so far tried butyl-xanthate alone has proved superior to ethyl-xanthate, but the additional recovery is hardly enough to warrant the extra cost of reagent. Potassium-ethyl-xanthate was used at first, but has been superseded by sodium-xanthate, which is equally efficient. Amyl-xanthate is decidedly inferior. Phospho-cresylic acid and some of its compounds are fairly satisfactory.

Preliminary work in the laboratory on amygdaloid ore indicated that soda-ash was better than lime, but after experimenting with it in various amounts in the mills its use was found to be unnecessary and it was discarded with no ill effects. The only reagents used are:

Sodium-ethyl-xanthate	.05 lbs. per ton
Pine oil	15 lbs. per ton

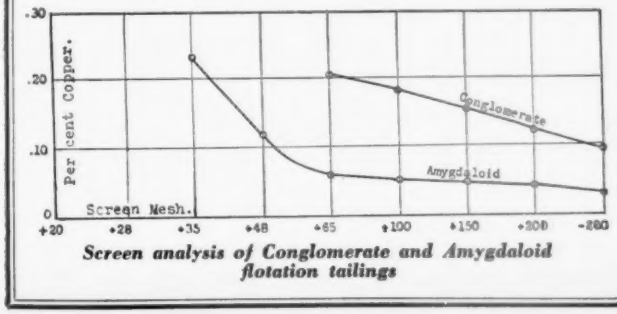
G. N. S. No. 5 pine oil containing 3 percent A. T. & T. No. 11 pine oil is used. The oil consumption is higher here than in western practice, as it is impractical under local conditions to settle the mill tailings and reuse the water.

The ordinary pulley-type reagent feeder is used in the mills because it is simple, foolproof, and inexpensive. The summers are cool and without great temperature variation between day and night as in the southwest and the mills are steam-heated for about seven months in the year so that the viscosity of reagents is not changed sufficiently to alter the rate of oil feed and affect the flotation circuit.

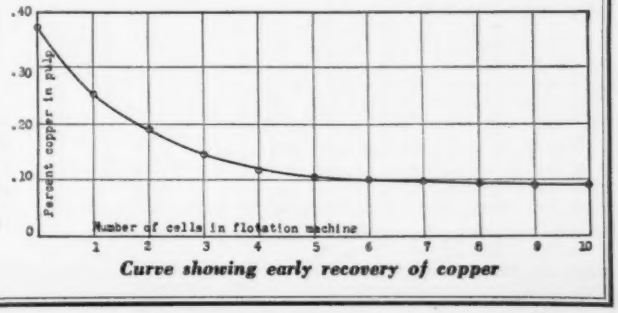
Flotation on Amygdaloid

With the amygdaloids it is relatively easy to separate the copper from the gangue so that crushing through 48 mesh gives a final tailing assay of .02 to .05 percent, depending upon the lode and its grade.

Where regrinding and flotation of the entire stamp product is practiced the



Screen analysis of Conglomerate and Amygdaloid flotation tailings



Curve showing early recovery of copper

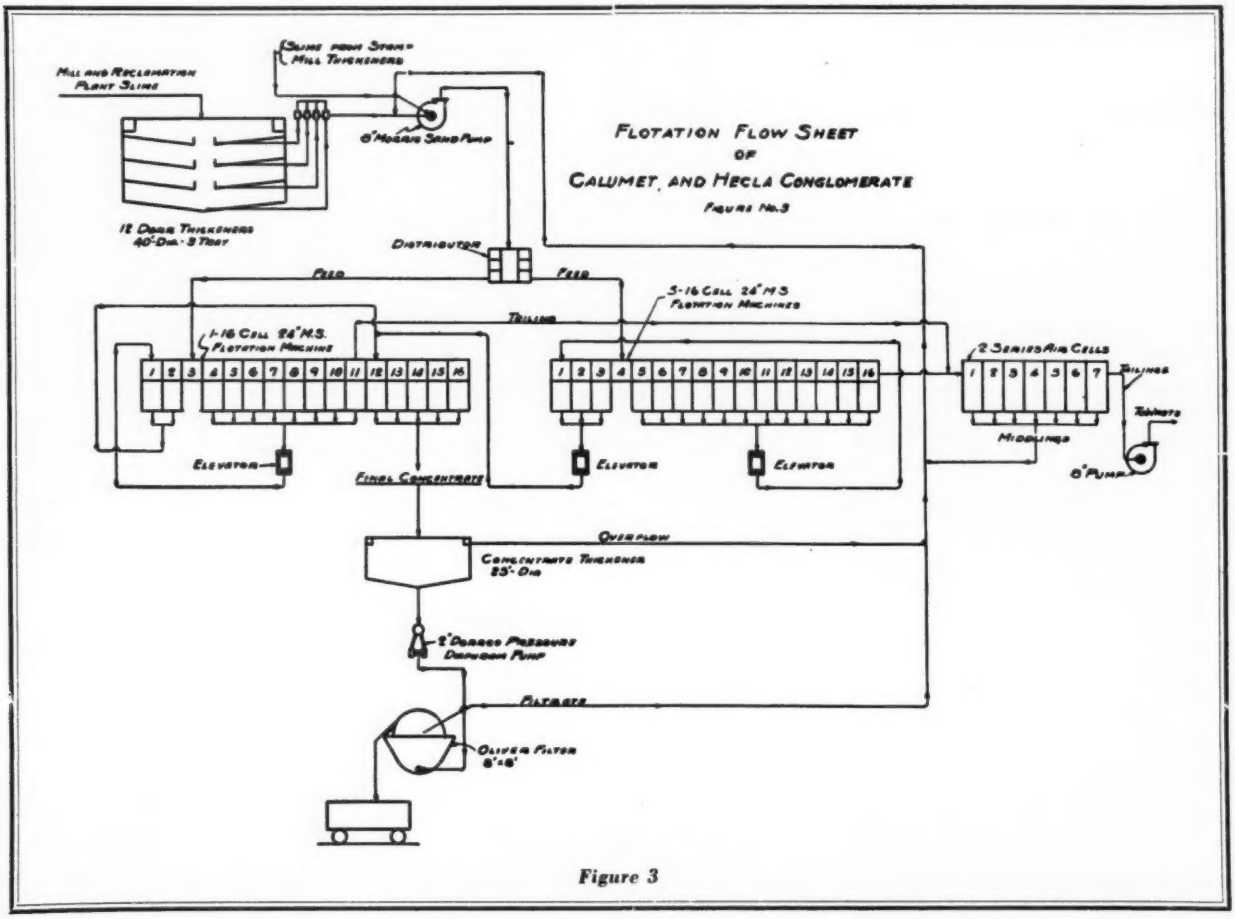


Figure 3

reagents are added to the ball-mill feed. The pulp density overflowing ball mill classifier is 40 percent solids, but this is lowered to 30 to 33 percent solids for flotation.

Of the 800 tons of rock stamped per head about 620 tons goes through the Fahrenwald machine (*Figure 4*) and most of the balance (primary slime overflow) goes to six 25-ft. diameter 3-tray thickeners in the mill basement, the thickened slime being elevated by means of six 4 in. diaphragm pumps to a 40-ft. Forrester flotation machine, which does very good work on this class of material.

The flotation circuit is simple. The feed enters the first cell of the Fahrenwald machine and a final concentrate is taken from the first two cells. From the remaining cells a rougher concentrate is made which flows by gravity into a side passage in the first cell directly over the impeller, thus avoiding the use of an elevator. This coarse concentrate averages nearly 60 percent copper, so retreatment is not necessary. Increasing the grade of concentrate much above this point increases the tailing loss materially. As regards operating conditions on the flotation machines it is advisable to carry a very high pulp level and comparatively small amount of froth for best results in saving the coarser particles of copper. Flotation of most of the copper is rapid, as the following curve shows:

Some of the heaviest particles lag behind and are recovered only in the final cells.

The flotation tailing flows to a 4-ft. 6-in. Dorr duplex classifier which makes an overflow averaging about .04 percent copper that amounts to 80 percent by weight of the tailing and is discarded. The sand product from the classifier is split between four Wilfley tables upon which a small amount of copper is recovered that has proven to be too heavy to float. The tables make a middling which is cleaned up on a finisher table, and the table tailings are combined with the classifier overflow as a final tailing to be pumped to the lake. The tables save about a pound of copper per ton treated, which lowers the flotation tailing approximately .01 percent copper. The table concentrate is high grade. As only a small amount of coarse sand is treated any change in the flotation circuit is magnified so that these tables make exceptionally good pilots.

The flotation concentrate is pumped to a drag classifier for removal of the coarse copper. The drag overflow flows to a 30-ft. traction thickener and the thickened product is elevated by means of a 2-in. pressure diaphragm-pump to the classifier discharge in order to wash the heavy copper into the filter. This latter is a 6 ft. by 4 ft. Dorrco fitted with a short belt conveyor for discharging the filter cake into a concentrate bin which can be emptied into 50-ton hopper-bottom cars for shipment to the smelter. The filter cake carries about 11 percent moisture and the dry assay is 55 to 60 percent copper.

The filter is run with an overflow which was at first returned to the concentrate thickener. This caused the slime to build up and make a dirty overflow. Later the filter overflow was returned to the Forrester flotation machine, resulting in a better grade of concentrate without raising the flotation tailing. The overflow of the concentrate thickener under these conditions is clear and remains so when operating conditions are normal.

Typical screen analyses of flotation feed and tailing and final tailing after tabling are as follows:

Mesh	Flot. Feed		Flot. Tailing		Final Tailing	
	Percent Wt.	Assay	Percent Wt.	Assay	Percent Wt.	Assay
+35	7.9	.50	8.4	.45	7.7	.23
+48	9.0	.50	10.0	.20	9.0	.12
+65	14.0	.52	14.7	.08	15.1	.06
+100	17.1	.46	17.1	.05	17.3	.06
+150	6.9	.42	5.6	.05	5.7	.05
+200	4.6	.44	3.1	.05	6.6	.04
−200	40.5	.19	41.1	.03	38.6	.03
Total	100.0	.37	100.0	.09	100.0	.07

The Historical Development of

SMELTING *and* REFINING Native Copper

By H. D. Conant*

WITH the beginning of copper mining in the Lake Superior region of Michigan about the year 1847, a new feature was introduced into the metallurgy of copper. Before that time copper had been obtained from sulphide or oxide ores by a smelting process that involved several operations for separating the metal from the sulphur, iron and other impurities with which it was combined in the natural state. The product of the Lake Superior mines is native copper, and no complicated processes are required to prepare the metal for use in industry; it is necessary only to melt the concentrates and massive copper, remove the slag formed by the rock in which the copper is found, and then, by a simple refining operation, to prepare the metal for pouring into the various shapes required by manufacturers. Both melting and refining were formerly performed in the same furnace, but as practice has improved, the two functions have been separated and are now generally performed in different furnaces.

When the Lake Superior copper mines began operation, the concentrates were shipped either to the Revere Copper Works near Boston, or to the copper smelter at Baltimore where the sulphide ores of the Atlantic states had been smelted for many years; but in the year 1850, owing to dissatisfaction with the quality of copper produced at those works, and in order to reduce expense, four of the largest copper rolling and brass manufacturing companies in Connecticut joined in constructing a copper smelting works at Detroit, Mich., of which the present Calumet and Hecla smelter is a direct outgrowth.

At the Detroit works there were at first one small reverberatory furnace for smelting the concentrates from the mines and refining the copper and one small cupola for recovering the copper contained in the slag taken from the reverberatory furnace. The maximum furnace charge of refined copper was limited to about 16,000 lbs., while today charges of 600,000 lbs. are common. In 1861 a copper smelting works was built and put in operation on the shore of Portage Lake, opposite Houghton, in the mining district of Michigan. The equipment was of the same type as at the Detroit works and one description will apply to both.

The reverberatory furnaces were used for melting the mineral, as the concentrates from the stamp mills at the mines are called, and the massive copper which ranged in size from pieces weighing a pound or less to some that weighed ten or fifteen thousand pounds. The concentrates and smaller masses were shipped to the smelter in barrels—thus giving rise to the term "barrel work" for the smaller pieces. At the smelter the barrels were emptied on the floor alongside the reverberatory furnace and the concentrates shoveled into the furnace by hand, while the heavy masses were lifted by hand-operated jib cranes and lowered into place through a large opening in the top of the furnace. Charging the furnace was usually done during the afternoon and the melting was accomplished during the night; the slag formed by the portion of crushed rock that remained in the concentrates and mass was skimmed from the furnace as the charge melted, and by morning the furnace held only clear molten copper ready for refining. Following the old Welsh methods, the first step in refining was to remove impurities by oxidation, called rabbling. This was accomplished by forcibly splashing the copper up into the air with a rabble—a hoe-like implement with a 4 by 6-in. blade and a long iron handle. While the impurities were being oxidized in this manner, they formed a slag that floated on the surface of the charge and could be easily skimmed off. As some copper oxide was formed in this operation, the next step was accomplished by burying the ends of hardwood poles in the copper, permitting the carbon in the wood to unite with the oxygen in the copper which left the latter in a pure metallic state. On the completion of refining, the copper was poured into molds of various shapes, some for small ingots used in brass making, some for flat

* Superintendent of Smelter.

square cakes for rolling into sheet copper, and some for bars suitable for drawing into wire. The ingot molds made of copper and the wire bar moulds made of cast-iron were set on the edge of a tank of water into which the cast copper, after solidifying, was tipped and cooled. The cast-iron cake molds rested on the floor and were deep enough to permit five or six cakes to be poured, one on top of the other, each cake being allowed to solidify and chill slightly before the next was poured. After the cakes had cooled they were pried apart with chisels. The copper was dipped out of the furnace by men with small long-handled iron ladles holding from 15 to 20 lbs. each; these were carried across the floor and their contents poured into the molds. In pouring a flat cake, which might weigh between 150 and 300 lbs., from four to eight men, according to the size of the cake, stood around the mold with filled ladles poised ready to pour the copper simultaneously at a given signal so as to completely cover the bottom of the mold at one pouring; other ladlers followed in quick succession until the full thickness of the cake was attained. This method, inefficient as it was spectacular, has passed into history.

In 1886 the Calumet and Hecla Mining Company, whose product had for 20 years been smelted at the Portage Lake smelter, built a plant of its own near its stamp mills on Torch Lake. This was followed in 1888 by the erection of a somewhat similar plant at Dollar Bay on Portage Lake by the Tamarack and Osceola Mining Companies, which companies were later consolidated with the Calumet and Hecla. At neither of these plants was there any departure from the old established practice and equipment; reverberatory furnaces of the conventional size and type were housed in each of the four corners of dimly lighted stone buildings.

The first radical change from the simple furnace refining of lake copper was made in 1894 by the Calumet and Hecla Mining Company at its branch smelter erected at Buffalo, N. Y., in 1891. At that place an electrolytic plant was constructed for the purpose of purifying the copper obtained from reverberatory slag and for recovering silver from that portion of the concentrates that carried it in paying quantities. The cathode product and the richer grades of mill concentrates were melted together, resulting in a copper product of higher electrical conductivity than could otherwise have been obtained without excessive furnace treatment. The size of reverberatory furnaces was gradually increased from time to time until they had a capacity of about 30,000 lbs. of copper; but aside from the introduction of the electrolytic treatment, no change in method was made until 1898 when, at the Dollar Bay smelter ,a reverberatory furnace measuring 40 ft. in length was built for melting concentrates, with provision for drawing off the slag and accumulating within the furnace molten copper that was permitted to flow by gravity at intervals of from 8 to 12 hours into one of the existing smaller furnaces for refining. At this same time casting machines were built and installed. In these machines the copper molds were supported by cast-iron plates provided with rollers and connected by link belt chains that passed over sprocket wheels at each end of the steel frame forming the body of the machine. At first the copper was dipped from the furnace and poured into the molds by means of ladles holding from 100 to 150 lbs., which were suspended from overhead trolleys thereby permitting them to be moved in and out of the furnace and swung over the molds by hand. Later these ladles were superseded by larger ones operated by hydraulic power and into which the copper flowed direct from the furnace by gravity.

This practice of melting in one furnace and refining in another proved so successful that three additional melting furnaces of about the same size and type were built, the only difference being that in the latter the charge holes in the top were located along the sides, permitting the concentrates to protect the side walls from attack by slag and heat and thereby greatly reducing furnace repairs. This is the first instance on record of side wall charging, a process patented by others many years later and which has resulted in much litigation.

At the Buffalo plant in 1900 a reverberatory melting furnace in connection with a refining furnace, having a capacity of 100,000 lbs., was built and equipped with a Walker circular casting wheel permitting a charge of copper to be poured in less than a quarter of the time consumed previously and at much less cost. In the same year a second and larger electrolytic plant was built with a daily capacity of 40 tons, both this plant and the earlier one being arranged on the multiple system of deposition. With an ample supply of cathodes available, it was the practice to melt them in the refining furnace, the mineral being charged into the adjacent melting furnace from which molten copper was drawn, flowing through a spout from one furnace to the other to supplement the cathode copper already melted in the refining furnace. Several of the furnaces were at the same time provided with waste heat boilers, and an appreciable amount of steam was obtained at low cost to aid in the generation of electric current for the electrolytic plant.

In 1905 the practice of using sodium carbonate and lime to lower the arsenical content and raise the electrical conductivity of copper was introduced at the Dollar Bay works. A mixture of soda ash and lime in equal proportions was thrown over the surface of the furnace charge during the oxidizing stage of refining, forming a slag in which the oxidizing arsenic was absorbed and with which it was skimmed out of the furnace. This proved to be effective and less expensive than the former practice of using cathodes in the charge in order to dilute the arsenic, especially if the copper from which the cathodes were made did not contain enough silver to pay for the electrolytic treatment. The use of soda ash for this purpose has continued to the present time; but instead of shoveling it over the surface of the copper as at first, it is now blown through iron pipes into the copper below the surface, thus assuring more intimate contact with the arsenious oxide.

Early in 1914 the feasibility of burning pulverized coal in the reverberatory furnaces was considered as a factor of economy and efficiency, the use of that type of fuel having been general for many years in the cement industry and since 1912 for copper smelting in Canada. The advantages of burning coal in this form appeared so pronounced that it was decided to apply the system at the Dollar Bay works; but since powdered coal had not as yet been tried anywhere in the refining of copper, an expensive pulverizing plant was not considered advisable and a unit pulverizing mill of the type used in cement burning was chosen for the experiment. The trial was successful from the beginning, for not only was the melting accomplished readily, but the refining resulted in a more even grade of copper than had ever before been attained. Later on when the designs for the improved and enlarged reverberatory furnaces at the Hubbell works were made, there was also provided a capacious and efficient central pulverizing plant completely equipped for drying, fine grinding and distribution of powdered coal by means of compressed air to storage bins at each furnace.

In 1914 the Buffalo works were closed and all operations were transferred to the Hubbell works on Torch Lake where a new electrolytic plant of five million pounds a month capacity had been built, which would operate under the favorable condition of a low electric current cost owing to the utilization of exhaust steam at the stamp mills for generating power. Two 100-ton reverberatory furnaces, each of 200,000 lbs. holding capacity, had also been built and equipped with Walker casting machines and were used principally in the preparation of anodes for the electrolytic plant. The latter was closed in 1922 because of the lowering of silver values in the copper and the fall in the price of silver. These furnaces and their equipment were inadequate for making cakes and wire bars, while the constantly increasing proportion of low grade concentrates presented a problem in melting for which the existing furnaces were unsuitable. Plans were made accordingly for the construction of a large reverberatory melting furnace to melt all of the concentrates and deliver molten copper to the refining furnaces, and for enlarging and deepening the latter so as to hold as much as 600,000 lbs. of copper at a time. In connection with these improvements it was planned to replace the small casting machines with large Clark type wheels capable of handling copper at the rate of over 100,000 lbs. an hour. The completion of this construction marked the end of the transition from the laborious, expensive and inefficient methods of early times to the economical and efficient procedure of the present day.

This transition period has seen the passing of the blast furnace used formerly to smelt the slag that was skimmed from the reverberatory furnaces, during both the melting and refining stages, and to recover the copper carried by the slag in the form of silicate. Numerous attempts had been made to prevent copper from entering the slag while melting the mineral, but success was reached only after the application of pulverized coal. Now a slightly reducing atmosphere is maintained in the melting furnaces while oxidation of metallic copper is prevented by mixing coal or coke screening with the charge. This permits the immediate discard of the slag from the reverberatory melting furnace without further treatment; and as the refining slag can be effectively cleaned of copper in the melting furnace, the blast furnace has become unnecessary.

CALUMET AND HECLA CONSOLIDATED COPPER COMPANY

Figure 1. General view of the Calumet & Hecla's Smelting Works

Present Smelting Practice

By
Endicott R. Lovell*
and
Herman C. Kenny†

THE smelter is situated on the shore of Torch Lake about a mile from the Calumet and Hecla stamp mills. Torch Lake connects with Lake Superior by way of Portage Lake, thus affording an easy means for shipping copper by lake steamers and for receiving supplies. Rail shipments are made via the Mineral Range or the Copper Range railroads, which have connections with the Calumet and Hecla system.

Concentrates from the stamp mills are received at the smelter in standard-gauge bottom-discharge cars and are taken to the concentrates storage building. Mass copper from the mines as well as from the mills is received on flat cars and taken directly to the furnaces. The concentrates storage building is built with 10 large concrete bins, into which the concentrates are dumped from the cars. These bins, as shown in the diagram, are each 48 ft. long by 22 ft. wide by 21 ft. deep, and each provides storage capacity for 2,000 tons of concentrates, or a total available capacity of 20,000 tons. The steel framework for the building and the crane runway is carried on the bin walls. A traveling crane runs the full length of the building and is equipped with a 2-yd. bucket for reclaiming and mixing the concentrates. See *Figure 2*.

The gangue associated with all concentrates from the conglomerate lode except the flotation concentrates is ferruginous, whereas the amygdaloid gangue is silicious and contains considerable alumina. The flotation-concentrate gangue is not only silicious but high in alumina as well. The problem involved in bedding concentrates is to get an intimate mixture of the several varieties and grades in such a manner that the resulting product is self-fluxing. No fluxes are added to the concentrates before melting, but about 5 percent of coal or coke screenings is included in the mixture. Two classes of material are made from the concentrates by mixing —a rich mixture carrying about 75 percent copper and a low-grade of about 40 percent. The reason for this procedure is that the melting furnace is called upon to deliver a melted charge sometimes daily and sometimes less frequently, and by using the proper mixture the demand can be properly met. The operation following melting is so regulated that both mixtures will be used up in the proper proportion. Each mixture is bedded with coal in a separate bin and is mixed after each addition of new material by picking up the new concentrates with the grab bucket and dropping them in a different part of the bin, several times if necessary. See *Figure 3*.

Copper oxide from the ammonia leaching plants is stored in a separate bin and mixed with about 8 percent of coal screenings in the manner described. Fluxes—such as limestone, which is used with the mass copper—charcoal briquettes, sand, and other bulk supplies are stored in a second set of 10 smaller bins adjacent to the concentrate bins. One of the large bins is equipped with a filter bottom and an overflow for dewatering granulated slag from the refining furnaces. In a tunnel below both series of bins there are railroad tracks for

* Assistant Superintendent.
† Metallurgist.

Figure 3. Interior of concentrates storage building

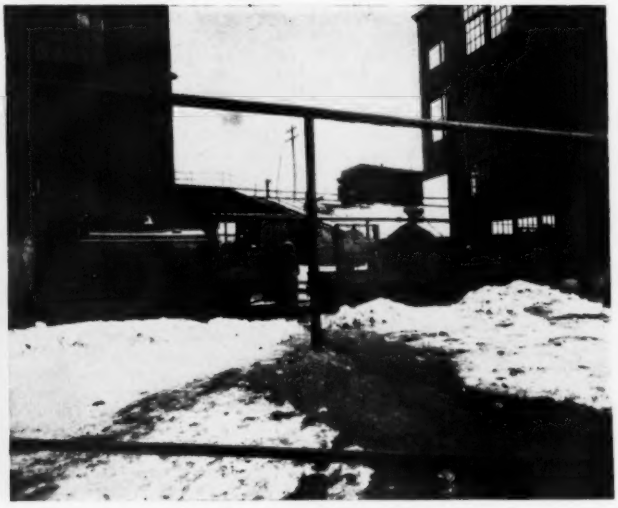


Figure 4. Scale car with charge leaving concentrates storage building

serving the furnaces. Concentrates are drawn off from the bins through gates into 150 cu. ft. scale-cars for charging. Scale car with charge leaving concentrates storage building is shown in *Figure 4*.

In considering the furnace operations, it must be borne in mind that the present furnace plant is an outgrowth from several units which preceded it, and, although a new plant would be somewhat differently arranged, the present equipment does very well indeed for the purpose. There are also several operations involved in the practice of smelting lake copper which do not conform to those used in matte smelting. For this difference there are very good reasons, although they are not always apparent. Except for the copper oxide from ammonia leaching, the entire metal content of the concentrates is native copper. The copper is too low in silver to warrant electrolytic refining and contains no gold whatever, and there are no other impurities which can not be removed by fire refining. A map of the smelter is shown in *Figure 5*.

The smelting operation consists of three essential steps: (1) melting, by which the metal is released and the gangue is removed as slag, (2) refining —that is, the removal of impurities by oxidation and slagging, followed by the reduction of the excess oxide by poling, and (3) casting the refined metal into shapes.

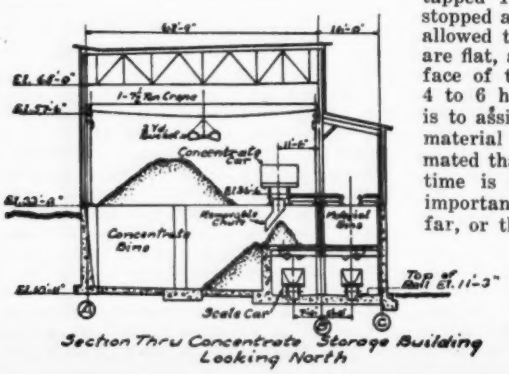


Figure 2.

The melting operation is carried out in a reverberatory furnace fired with pulverized coal. This furnace is equipped with tapping openings for slag on one side near each end and with a tapping slot for copper on the opposite side near the burner end. The wet furnace charge is brought from the concentrates storage building in scale weigh cars, which are hoisted with a crane and overturned into storage bins over the furnace. There are eight of these bins in line, made large so that the greater part of the concentrate handling can be done on the day shift. The furnace is charged from these bins through openings in the center of the arch. Center charging is practiced in lake copper melting furnaces, and is, no doubt, the most effective method under the circumstances. The practice is to charge a certain number of holes every two hours, or at longer intervals, depending on the rapidity of melting at the various points along the furnace. While the charging is going on, slag is being drawn off more or less continuously, starting from 4 to 6 hours after the first charge, or as soon as the slag becomes sufficiently fluid. The furnace atmosphere during the melting period must be kept slightly reducing. The reducing atmosphere, together with the coal screenings mixed with the charge, prevents oxidation of the metallic copper and subsequent loss of oxidized copper in the slag. At a time roughly 14 hours before the copper is to be tapped from the furnace, charging is stopped and the piles of concentrates are allowed to melt down. Before the piles are flat, air is introduced below the surface of the bath for a period of from 4 to 6 hours. The purpose of the air is to assist in bringing up the unmelted material from the bottom. It is estimated that about 7 hours of the melting time is saved in this manner. It is important not to oxidize the bath too far, or the slag losses will be high; but the material rising from the bottom brings up a mass of coal screenings with it and as long as a blanket of fine coal remains on the surface of the bath, the danger of oxidation is slight. Slag is not drawn off while the air-blowing is in progress. After the blowing is stopped, the slag is allowed time to separate, and the tapping is then resumed. From 2 to 4 inches of slag is allowed to remain on the bath and the copper is tapped from beneath it. The reducing atmosphere in the furnace causes the copper bath to retain a certain amount of iron and sulphur in solution, but the oxidation removes a considerable part of the iron.

Analysis of Melting Furnace Copper

Cu	98.7%
Fe	1.0%
S	0.2%
As	0.04%

The slag formed in the melting furnace would not be considered very desirable for a matte furnace, but it is quite fusible at a sufficiently high temperature. The following is an approximate average slag analysis for normal operation:

	Percent
SiO_2	42.5
FeO	30.0
Al_2O_3	13.0
MgO	2.3
CaO	8.0
Cu	0.60

As the slag leaves the melting furnace it is granulated in water and pumped 1,800 ft. through a 6-in. pipe line to the waste slag dump. Two pumps in series are used in this operation. Samples of the slag are taken automatically as it enters the second pump sump.

The smelter has learned from bitter experience that it is necessary to have sufficient spare furnace capacity to replace any unit on short notice. Therefore two furnaces for melting are available. The newer melting furnace, No. 20, is larger than the older furnace, No. 23, and is more advantageously placed. The intention is to use No. 23 as little as possible, but it must be kept in readiness in case of serious trouble with the newer furnace, such as a bottom replacement. No. 20 furnace is so located that

the molten charge of copper can be drawn off through brick-lined, cast-iron launders 50 or 60 ft. long to either of two refining furnaces located near it. Copper from No. 23 furnace must be carried to the refining furnaces in 10-ton ladles. A photograph of the interior of melting furnace No. 20 is shown in *Figure 6*.

Molten copper is not so easily handled as matte. In the first place, its melting point is much higher, and, unless it is heated considerably above the melting point, it will not run in the launders without freezing. The melting range of copper is so small and its heat conductivity so great that skulls will form rapidly if the melt is at all cold. Once skulls begin to form, it is usually good business to stop tapping immediately, but to do so is always very difficult and sometimes impossible if a very heavy cut has been made. For this reason, it has been the custom to melt practically the entire charge and allow the bath to heat up before tapping copper. It is very difficult to raise the temperature of the bath much above the melting point while unmelted copper still remains in the furnace. Attempts have been made to draw off copper while there were still piles of unmelted concentrates in the furnace, but these trials usually have been abortive. The density of the molten metal is so great that just about the time when tapping is to begin one of the piles will come off the bottom and the unmelted material will spread over the surface of the bath and chill the copper. If the piles are high enough to prevent them from rising, the bath will be too cold to tap. Attempts to obviate the expensive run-down operation are still being made and may prove successful. In drawing off copper under the slag layer, it is customary to chill the slag near the tapping opening by charging small amounts of concentrates at that point; the slag is then held back by a clay plug and copper is tapped from beneath it.

The construction of the melting furnace is shown in the accompanying sketches and photographs. All furnaces are equipped with water-cooled cast-iron side plates to prevent breakouts. Skew backs and charge-hole jackets are made of deoxidized copper and are also water-cooled. Water-cooled arc-welded steel dampers are used in all flues except after boilers. Some damper slots are also water-cooled. Circulating water is supplied from Torch Lake by centrifugal pumps.

Furnace foundations of melting and refining furnaces are of solid concrete except for longitudinal and transverse tie-rod ducts. Furnace bottoms are inverted silica brick arches, 18 or 20 in. thick. Under the bottom proper is a secondary inverted silica brick arch, usually 9 or 12 in. thick. The form of the inverted arch usually consists of brickbats or furnace concrete. Burned-in silica or sand bottoms are unsuccessful in Lake Superior practice.

The life of the brick work depends entirely on the production rate. At full capacity it is necessary to do some repair work, such as renewing a portion of the arch or patching the walls, every six weeks. These repairs usually entail a shutdown of not more than one or two days, which does not materially interrupt the operation of the plant. At three or four-month intervals a longer repair is necessary; the maximum lost time for a very extensive renewal of walls and arch would not be over one week.

Bottom renewals are a different affair. A bottom should last two years or more. The difficulty of removal depends upon the length of service. When a furnace bottom has to be renewed, the task of cutting out the old bottom is quite arduous. Since the bottom is thoroughly saturated with copper and can not be chipped out to advantage, underground mining methods of handling mass copper are resorted to. The old bottom is drilled with longitudinal and transverse rows of 1-in. diameter holes about 2 in. apart. the drilling being done with air-operated twist drills. These holes are charged in lots of 25 to 50 with 90 percent blasting gelatin, the whole is covered with sand bags and old rope, and the bottom is blasted out in sections.

The average daily capacity of No. 20 furnace when operating at full load is about 280 tons of concentrates, which will yield about 120 tons of slag. At this rate of firing about 75 tons of coal per day will be burned. The holding capacity of the furnace is roughly 500 tons of copper. Both melting furnaces are equipped with automatic damper reg-

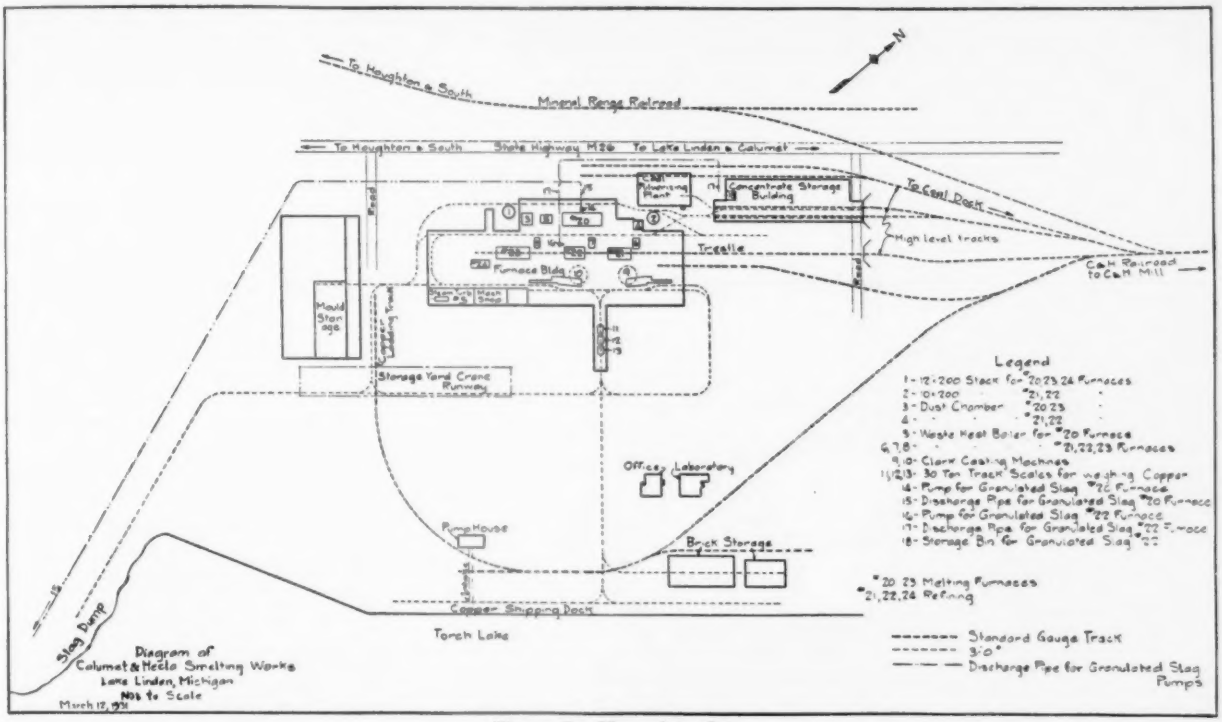

To Houghton & South
Mineral Range Railroad
To Houghton & South
State Highway M26
To Lake Linden & Calumet
Warming Plant
Concentrate Storage Building
To Coal Dock
High level tracks
Tressle
Furnace Bldg.
C & H Railroad to C & H Mill
Mould Storage
Storage Yard Crane Runway
Legend
1- 12-200 Stack for #20 23 24 Furnaces
2- 10-200 " #21, 22 "
3- Dust Chamber #20 23 "
4- " " #21, 22 "
5- Waste Heat Boiler for #20 Furnace
6, 7, 8- " " #21, 22, 23 Furnaces
9, 10- Clark Casting Machines
11, 12, 13- 30 Ton Track Scales for weighing Copper
14- Pump for Granulated Slag #22 Furnace
15- Discharge Pipe for Granulated Slag #20 Furnace
16- Pump for Granulated Slag #22 Furnace
17- Discharge Pipe for Granulated Slag #22 Furnace
18- Storage Bin for Granulated Slag #22
Offices Laboratory
Pump House
Brick Storage
#20 23 Melting Furnaces
#21, 22, 24 Refining
Copper Shipping Dock
Torch Lake
Standard Gauge Track
3'-0"
Discharge Pipe for Granulated Slag Pumps
Slag Pump
Diagram of Calumet & Hecla Smelting Works Lake Linden, Michigan
Not to Scale
March 17, 1931

Figure 5. Map of smelter

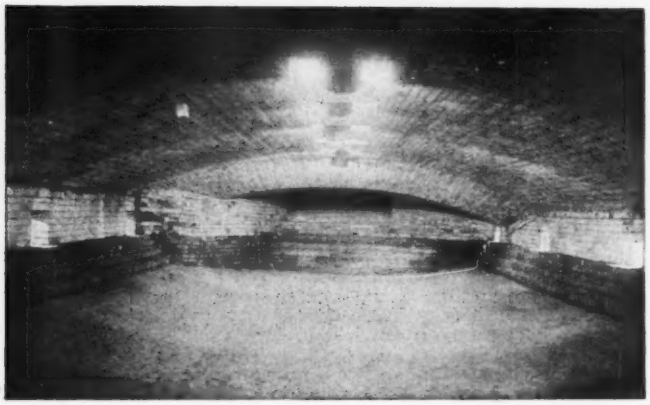


Figure 6. Interior of melting furnace No. 20

ulation and automatic carbon-dioxide recorders.

Cost of Melting Furnace Operation

	Per Ton of Concentrates
Attendance	$0.22
Fuel (Pulverized Coal)	1.57
Supplies	0.28
Motive Power — Crane — Tramway	0.06
Repairs—Labor	0.11
Repairs—Refractories	0.24
Handling Furnace Charges	0.32
Total Melting Cost	$2.80

The metal drawn from the melting furnaces is run to one of two refining furnaces of the standard type. These have a capacity of from 250 to 450 tons of molten metal, depending on whether the bottom and sides are new or very much worn. Either of these furnaces can be run at a rate sufficient to care for the entire production of copper in normal times. One is a spare for the other, and as nearly as possible they are duplicates. The construction of the refining furnaces is similar to that of the melting furnaces. The main differences includes the elimination of the "verb" and the use of jackets instead of bottom tie rods for binding the ends of the refining furnaces. See diagram of refining furnace No. 22 in *Figure 7* and a section through No. 20 and No. 21 furnaces in *Figure 8*.

In addition to the molten charge, copper oxide from the leaching plants is handled by these furnaces. Since the oxide is very corrosive to brick work, it is customary to protect the bottom and sides of the furnace, especially near the tapping slot, with a blanket of rich concentrates. This material is charged into the furnace, together with whatever refining scrap or scrap molds or mine mass is available, before the molten charge is run in from the melting furnace. Small mass copper is charged directly into the melting furnace through a chute provided for the purpose, but the larger pieces are charged into the refining furnaces through a covered water-cooled opening in the arch. To prevent explosions of the copper oxide, which can be quite serious, or in any event, spectacular, it is necessary at least to partly melt the charge already in the furnace before adding molten metal.

As soon as the molten charge is in the furnace, oxidation of the bath with air commences. Compressed air is intro-

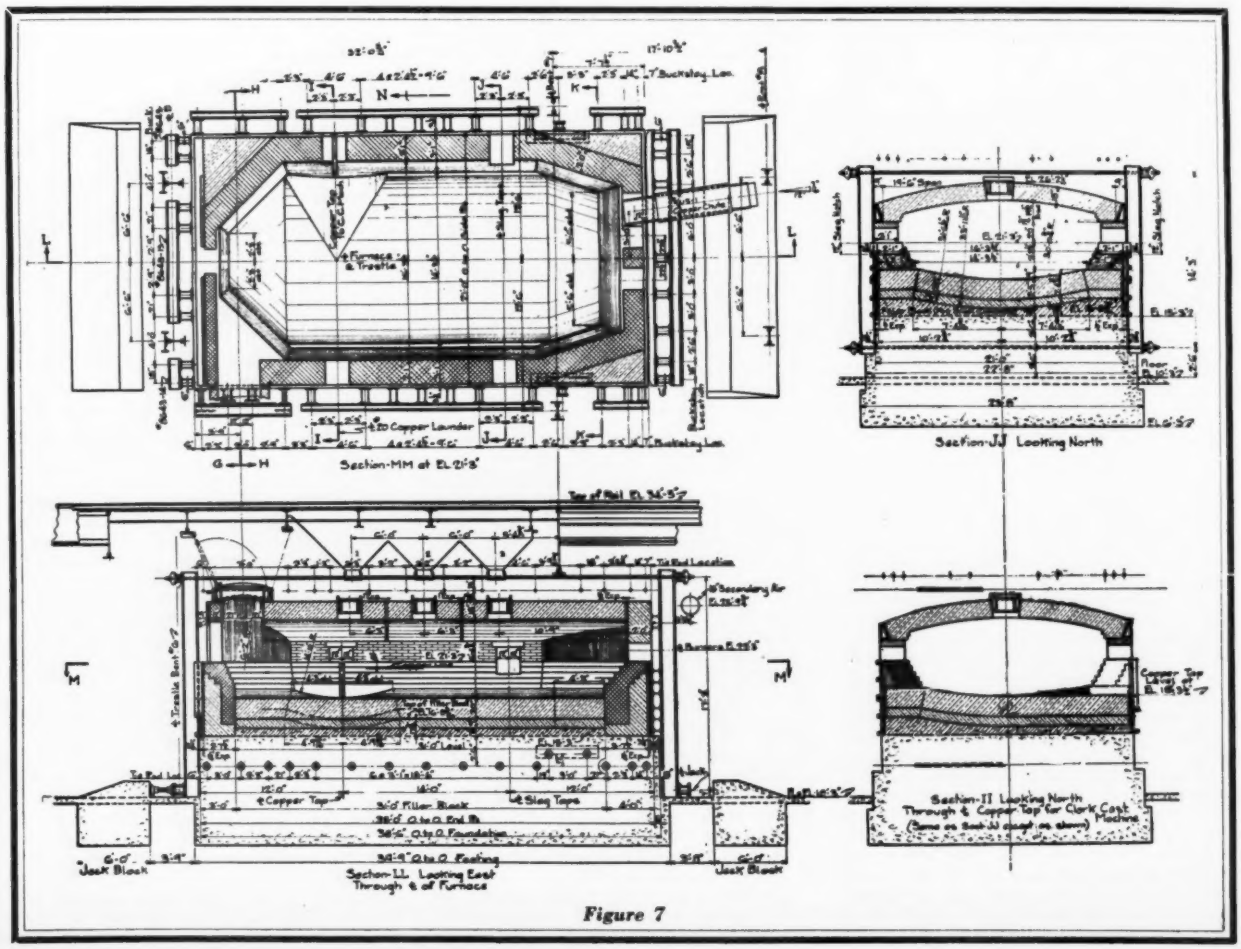

Section-MM at El. 2'8"
Section-JJ Looking North
Section-II Looking East Through ℄ of Furnace
Section-II Looking North Through ℄ Copper Top for Clark Cost Machine

Figure 7

duced under the surface of the bath through iron pipes covered with a refractory cement. This is done at as many points as possible so that the charge will be fully oxidized by the time it is completely melted. In order to remove the iron and sulphur as rapidly as possible, the oxidation is carried further than in refining cathodes. During the oxidizing period, the iron removed from the bath would ordinarily form an infusible slag on the surface, but the charge is rapidly analyzed for iron before refining and a sufficient quantity of sand is thrown onto the bath to flux the iron oxide as it is liberated. This treatment results in a very fluid slag which is skimmed off, granulated in water, and pumped to the filter bin in the concentrates storage building. There it is dewatered, mixed with coal screenings, and added to the melting furnace charge. A Hummer screen is provided before the slag pump to remove from the granulated slag brick and unmelted lumps, which are always present in varying amounts.

All the furnace charges contain arsenic which may be removed to meet electrical-conductivity specifications after the iron and sulphur have been eliminated. The removal is accomplished by blowing powdered soda ash into the bath. The soda forms a fluid slag which absorbs arsenic readily. The soda slags, being very corrosive, must not be allowed to remain on the bath too long.

After the arsenic is removed, or even while it is being removed, poling is started to reduce the excess oxygen in the bath, Green hardwood poles are used in the poling process. The oxygen content of the bath is reduced to 0.04 to 0.05 percent, which is about right for tough pitch copper, and the metal is ready for casting.

In casting the copper, the metal is drawn off from the furnace into tilting ladles which supply the molds. The molds are of cast copper and are placed on a casting wheel of the Clark type, which has a capacity, depending upon the shape cast, of from 60,000 to 140,000 pounds per hour. The operation is continuous. As soon as the metal has set in the mold it is automatically dumped into a water bosh, and is removed from the bosh by a pan conveyor onto an inspection table, also a part of the conveyor system, where imperfections are removed by chipping and where imperfect castings are discarded.

Figure 9. Clark casting wheel

Refining Costs

	Per Ton of Copper
Attendance	$0.40
Fuel (Pulverized Coal)	0.57
Poles for refining	0.32
Fluxes	0.49
Other Supplies	0.17
Motive Power—Crane—Tramway	0.08
Handling Slag	0.15
Repairs—Labor	0.20
Repairs—Refractories	0.53
Total	$2.91

Copper molds are made on hydraulic mold presses, either water-cooled copper or cast-iron cores being used. Copper for these molds may be conveyed from any of the three refining furnaces to the presses either by means of crane-supported ladles or direct by gravity.

The multiplicity of shapes required by copper consumers necessitates tying up an immense stock of copper in molds. Wire bars are made in all sizes and flat cakes, wedge cakes, and slabs of many varieties must be produced as called for. Mold storage presents a problem. Molds must be readily accessible for the casting machine and still can not be allowed to occupy valuable space. A building formerly used for electrolytic tank house has been remodelled and serves very well for storage purposes. It is not uncommon to have 5,000,000 pounds of copper on hand as molds. See *Figures 9, 10* and *11* for photographs of casting wheel, inspection and mold storage.

From the inspection table the cast shapes are loaded on narrow-gauge flat cars, weighed, and taken either to the smelter dock for lake shipment or to a storage yard served by overhead cranes. From the storage yard the copper may be loaded into railroad cars by means of a crane and an electric lift truck.

Cost of Casting Refined Copper

	Per Ton of Copper
Operating Labor	$0.40
Supplies and Power	0.08
Inspecting and loading copper	0.41
Making New Molds—Labor	0.09
Making New Molds—Supplies	0.09
Total Casting Cost	$1.07

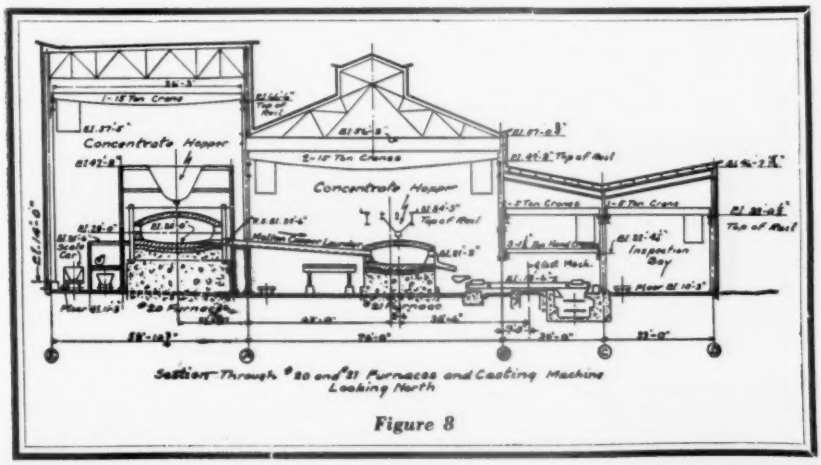


Figure 8

In addition to the regular refining furnaces there is a furnace of about 75 tons capacity equipped for trolley-ladle dipping. This small furnace was built for casting billets and for making up small orders of special shapes which could not be made economically at the larger furnaces. The furnace operates intermittently as orders for billets accumulate. It is so arranged that a large opening in the arch can be used for charging unusually large pieces of mass copper and sections of old furnace bottoms.

All furnaces are fired with pulverized coal. The coal pulverizing plant is centrally located and the coal is blown from a weigh tank in batches of five tons to bins serving each furnace. The coal plant is equipped with a single roll

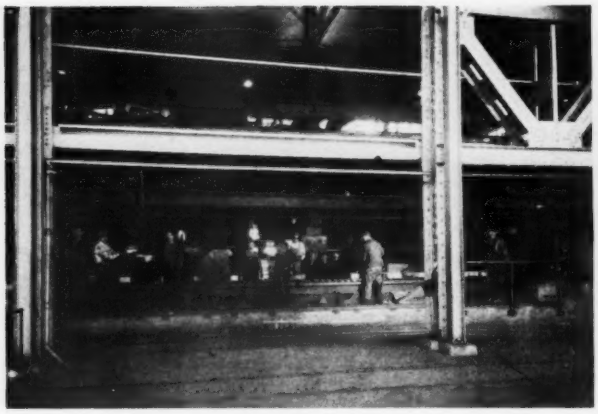


Figure 10. Copper inspection

Figure 11. Mold storage

crusher, magnetic belt separators, 100-ton crushed-coal bin, Ruggles-Coles doublepass dryer, and two Raymond six-roller mills. A washer and a Dracco filter are used to remove dust from the drying and grinding systems respectively. The building was designed to provide for duplication of drying and grinding units if the necessity should arise. The coal burned is a very good grade of high-volatile bituminous, having an ash content of from 3 to 6 percent, sulphur always below 1 percent, and a heating value of from 14,200 to 14,700 B. t. u. per pound. Since the moisture content is very low, in summer it is sometimes possible to dispense with the drying operation. In winter, on account of the snow on the stock piles and coal cars, drying is always necessary. An effort is made to keep the moisture content of the pulverized coal below 1 percent. The fineness varies from 75 to 85 percent through the 200 mesh, depending upon the condition of the mills. Pulverizing costs are slightly over $0.50 per ton of coal.

All furnaces are provided with waste heat boilers which can be by-passed if necessary. The melting furnaces have dust chambers following the boilers. These melting-furnace boilers are arranged for pulverized coal firing in case a furnace should be shut down and additional steam should be desired. The waste heat boilers on the melting furnaces give very fair performance records in spite of the heat taken up in the furnace. Evaporations of 7 to 1 from and at 212 degrees F. are not uncommon on the total coal burned in the furnace. The gas temperatures entering the boiler may be as high as 2,300 to 2,500 degrees F. and those leaving the boiler will be about 600 degrees. Steam is used for running an 800-kw. turbine generator and for other miscellaneous steam-driven equipment and also for heating the buildings in winter.

Three brands of copper which are classified by arsenic content are produced at the smelter. Typical analyses of these three brands are given in an accompanying table.

The standard specifications of the American Society for Testing Materials for low resistance Lake copper are the same in all particulars as those for electrolytic copper. Prime C&H is used in all sizes of wire for electrical purposes. On account of its inherent high native purity, toughness, ductility, and tensile strength, prime C&H sheet and strip copper enjoys popularity in the trade for many uses, such as washing machines, automobile radiator cores, and refrigerators.

Typical Analysis of Three Brands of Copper

	Prime C&H Percent	Natural C&H Percent
Copper plus Silver.	99.9500	99.9100
Arsenic	0.0025	0.0445*
Iron	0.0025	0.0025
Nickel	0.0015	0.0015
Sulphur	0.0015	0.0015
Oxygen	0.0420	0.0400
	100.0000	100.0000

CL percent arsenic varies in CL grade from 0.06 to 0.50. Other impurities same as other grades.

* Arsenic may vary from 0.02 to 0.06.

Natural C&H and C L brands are specified for architectural work, owing to the increased strength and resistance to corrosion imparted by the arsenic. This metal is also used in European practice for locomotive fireboxes and staybolts.

In addition to these brands some metal is sold on the basis of silver content. High-silver Calumet & Hecla copper, which maintains its strength at high temperatures, is used for special purposes where this requirement must be met.

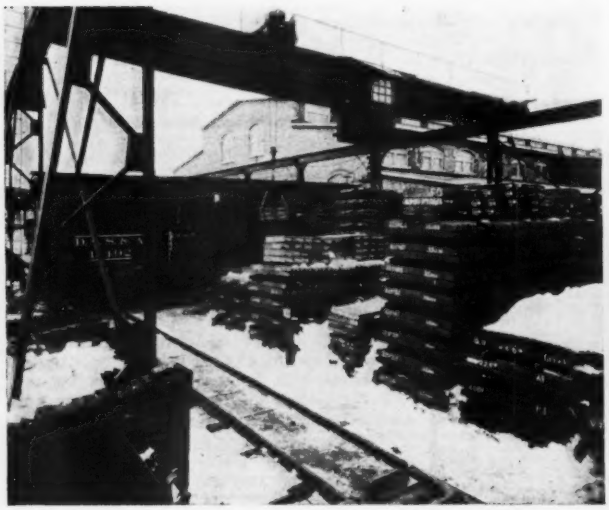


Figure 12. Loading copper for rail shipment at storage yard

Figure 13. Loading copper for Lake shipment at copper dock

CALUMET AND HECLA CONSOLIDATED COPPER COMPANY

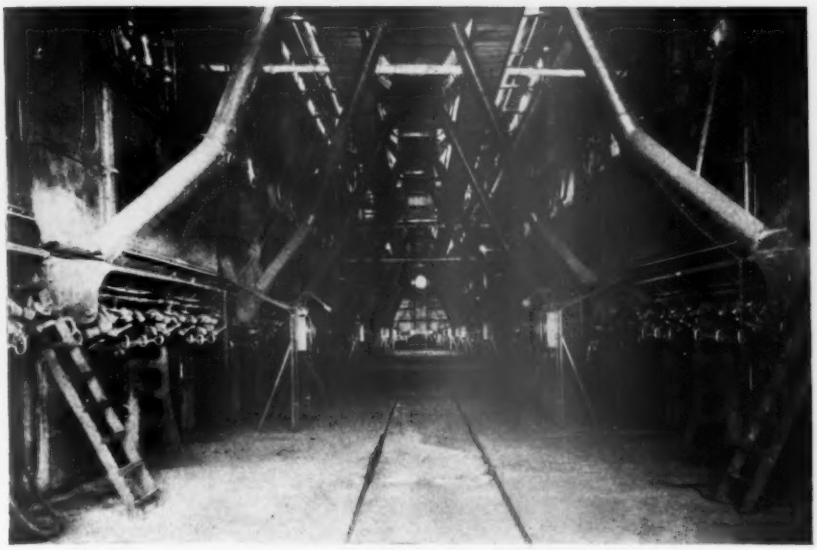


Figure 1. Boiler house at Lake Linden

Electric Power Generation

By
Robert McIntosh*
and
A. L. Burgan†

ELECTRIC power used by the Calumet & Hecla Consolidated Copper Company is generated by steam turbines at its mill and smelter plants. These are located along Torch Lake, which gives good condensing water facilities. The coal dock is adjacent, and a canal connecting to Portage Lake and through this to Lake Superior makes the dock accessible to all lake steamers. Thus excellent West Virginia coal is available at a low freight rate. These factors, together with economy resulting from the use of exhaust and process steam and waste heat, make for a low cost of power.

Power is generated at 25 cycles, 3 phase, with 13,600 volts on outside and interconnecting lines. There are eight turbines arranged to operate in parallel as one system. Their total generating capacity is 31,800 kw. at 80 percent power factor, or about 40,000 kva. They are located as follows:

At the LAKE LINDEN POWER PLANT

No. 1 turbine—8,000 kw. mixed pressure.
No. 2 turbine—9,000 kw. mixed pressure.
No. 3 turbine—2,000 kw. low pressure.

In the Still House at Lake Linden

No. 4 turbine—1,250 kw. back pressure.

At the SMELTING WORKS

No. 5 turbine—800 kw. on waste heat boilers.

At the AHMEEK MILL

No. 6 turbine—2,000 kw. low pressure.
No. 7 turbine—1,250 kw. back pressure.
No. 8 turbine—7,500 kw. high pressure.

The kw. ratings given are for 80 percent power factor and 40 degrees Centigrade temperature rise with the exception of turbines 4, 7 and 8, which are rated for 50 degrees rise.

At the Lake Linden boiler plant, built in 1908, there are 24 512-hp. Babcock and Wilcox boilers. (*Figure 1.*) Roney stokers are used with natural draft. Coal is delivered in railroad cars over a hopper leading to a link-belt double-roll crusher. It is crushed to 1 in. size and delivered to overhead coal bunkers by a Peck carrier. Each boiler is fed by a separate chute from the bunkers. The ash pits discharge to launders below them, pitched ¼ in. per foot, through which the ashes are flushed to a central sump. Coarse clinker is crushed through grate bars at the top of the sump box to prevent choking the cen-

Figure 2. Power plant at Lake Linden

* Mill Superintendent—Lake Linden Plants.
† Mill Superintendent—Ahmeek and Tamarack Plants.

Figure 3. Ahmeek Mill and Power Plant, looking east. Above the concrete are the steel ore bins served by a double track. Coal chutes under the rear track lead to coal bins built into the concrete supporting structure.

power plant and through an 8-in. pipe to the still house turbine. Steam for steam stamps, pumping, heating systems, and leaching, passes through a reducing valve set at 140 lbs., thence through a 24-in. pipe to the mills. Flow meters in each of these mains give the basis for steam charges to power, mill purposes and distillation. Each boiler is equipped with a Bailey meter, recording steam flow, air flow, and flue gas temperature, and indicating draft over the fire.

Figure 4. Ahmeek Mill Boiler House. Operating floor showing stokers, main steam piping and control panels.

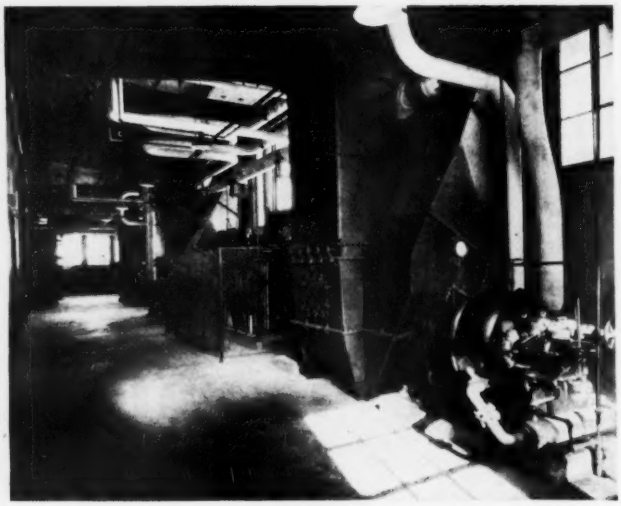


Figure 5. Ahmeek Mill Boiler House. Forced draft fans with steam turbine drives.

trifugal pump which delivers the ashes to a sand-wheel to be disposed of with mill tailings.

Feed water is largely condensate from the surface condensers of the turbines and general heating system drains. Steam used for leaching and distillation in the ammonia leaching process is necessarily lost from the system so that considerable make-up is required. Raw Lake Superior water is used for this purpose. Cold feed water is circulated through ammonia condensing and cooling apparatus in the still house, accomplishing the necessary cooling without waste of mill water and substantially raising the feed water temperature. This is then brought up to about 200 degrees F. in open feed water heaters taking exhaust steam from the boiler feed pumps and steam stamps.

Each boiler is equipped with soot blowers which are operated at 8-hour intervals. After four or five weeks of service boilers are cut out for external washing and furnace repairs, and on alternate washings the tubes are turbined for scale removal.

Steam is generated at 180 lbs., at which pressure it is supplied through an 18-in. pipe to the turbines in the

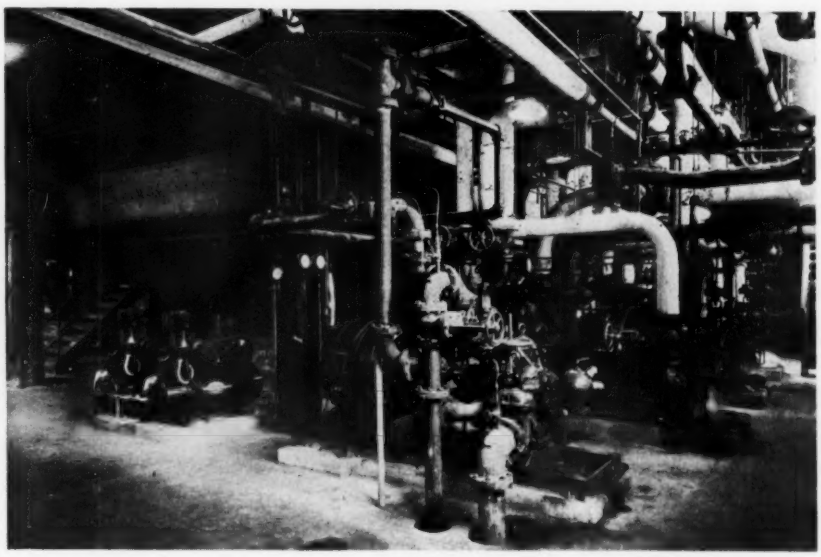


Figure 6. Ahmeek Mill Boiler House. Control compressors, ash pump and boiler feed pump.

The power house, (*Figure 2*) separate from the boiler house, contains two Allis-Chalmers mixed-pressure turbines of equal size connected to generators of 8,000 and 9,000 kw. capacity, respectively, and one General Electric 2,000 kw. low-pressure turbine. The low-pressure turbine is connected to an independent 6-in. high-pressure steam line from the boilers for use should its power be needed when low-pressure steam is not available. Old reciprocating units which the turbines replaced have been removed, two of their generators being retained for use as synchronous condensers.

TABLE 1

	Kwh.	Percent of total
Lake Linden plant from high-pressure steam	101,053,000	76.0
Lake Linden plant from stamp exhaust	10,750,000	8.1
Lake Linden still house from process steam	2,763,500	2.1
Smelting Works waste heat	5,686,800	4.3
Ahmeek mill stamp exhaust	12,746,200	9.5
Total	132,999,500	100.0

The two mixed-pressure turbines each have a h'gh- and a low-pressure cylinder,

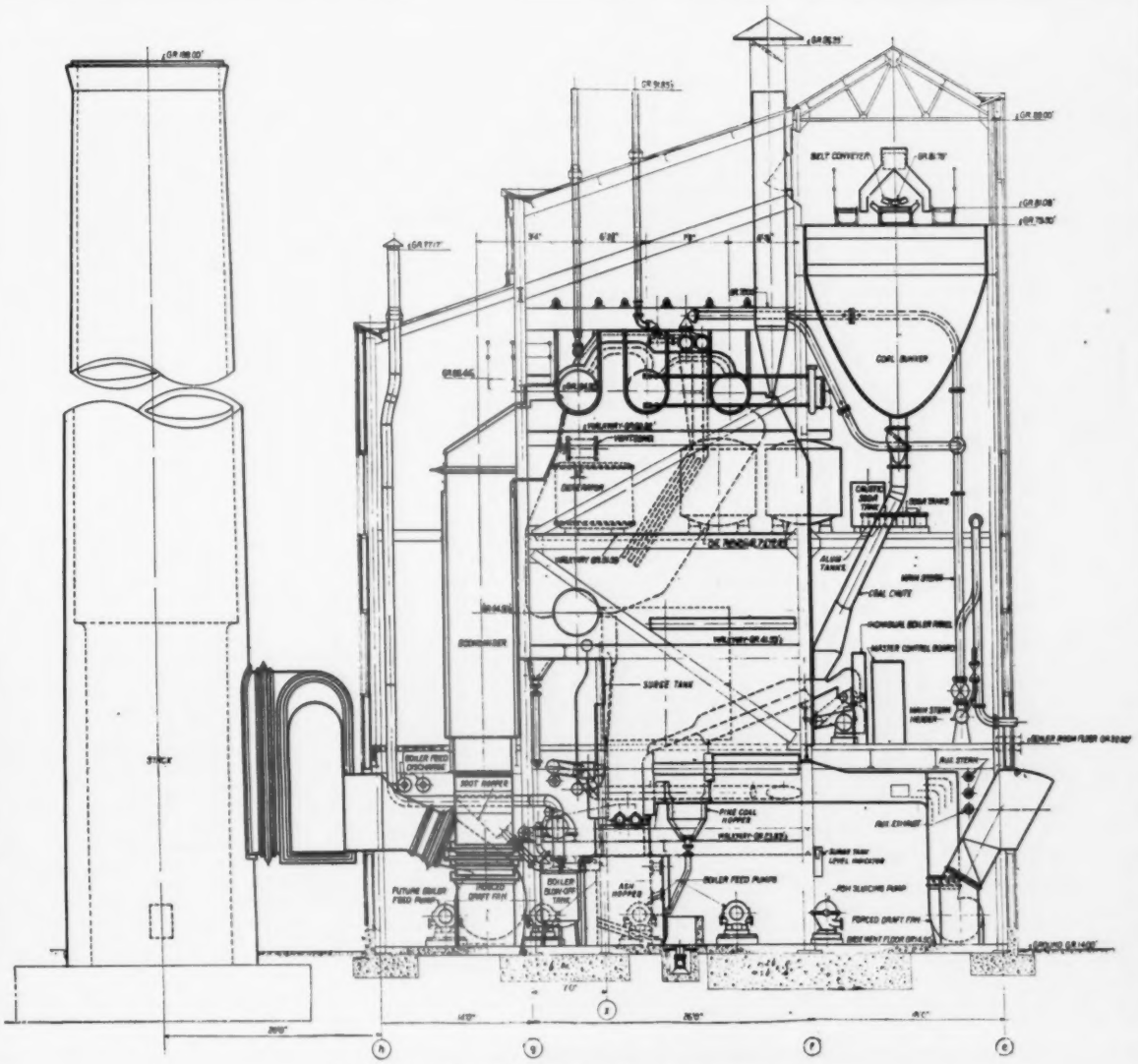


Figure 7. Ahmeek Mill Boiler House. Cross section.

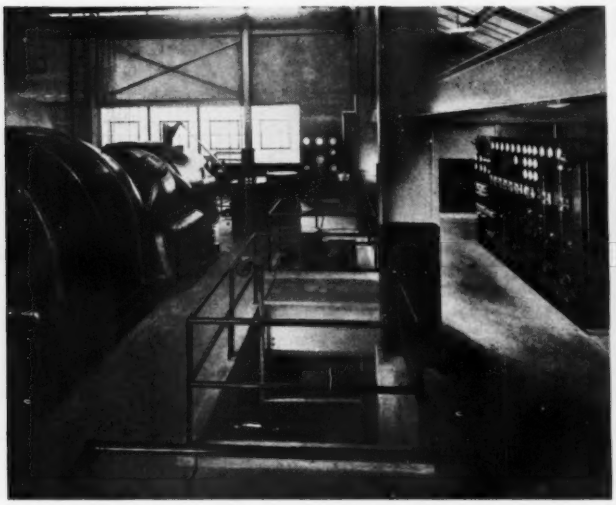


Figure 8. Ahmeek Mill Power House. No. 8 steam turbine generator unit with its 13,600-vold switchboard.

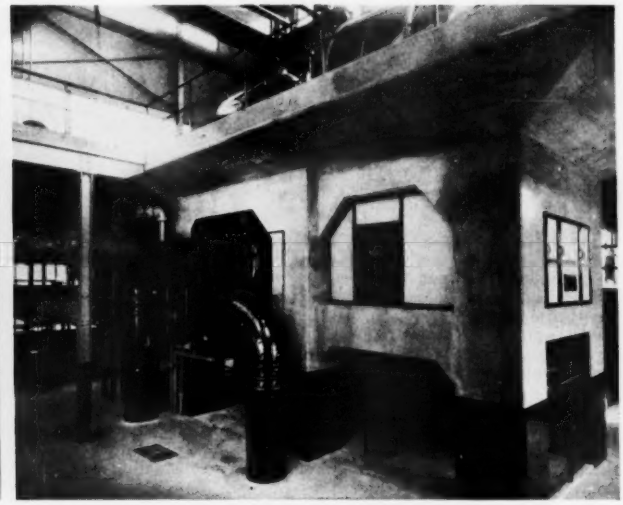


Figure 9. Ahmeek Mill Power House. No. 8 turbine room, showing reinforced concrete turbine foundation and condenser.

the high-pressure cylinders operating on boiler pressure of 180 lbs. and exhausting to receivers connected to the low-pressure cylinders. Exhaust from the steam stamps also comes to the low-pressure cylinders through a 36-in. pipe from the mill. Pressure in this line is maintained at about 1 lb. above atmosphere by flow regulating valves at the turbines, to insure against leakage of air into the system. This 36-in. pipe acts as a low-pressure steam reservoir into which comes exhaust steam from the stamps, high-pressure turbine cylinders, feed pumps, and if required, part of the exhaust from the still house turbine. From it steam is taken for the low-pressure cylinders of the turbines, feed water heating and the heating systems of the main mill buildings. When stamps are not operating, low-pressure steam for heating is still available from the mixed-pressure turbines which then act as bleeder turbines.

Circulating water is taken from the mill pumping system. The pump house is located at the shore of Torch Lake about 800 ft. distant from the power plant with the mills between them. The pumps in regular use there are a 30-in. Alberger centrifugal pump, motor driven, with a capacity of 40 million gallons per day, and the pump Michigan which is a triple expansion reciprocating steam pump of 60 million gallons per day capacity. Both operate against a total head of 60 ft. and either can supply water for condensing or mill purposes. Condensing water used in the power plant is returned for mill use by a 30-in. motor driven centrifugal pump.

Located in the still house is a 1,250 kw. DeLaval geared turbine unit receiving steam at 180 lbs. and exhausting at 18 lbs. above atmosphere, as required for use in distillation of copper-ammonia solution from the leaching plant. Its purpose is to utilize for the production of power the necessary drop in pressure. The amount of power produced depends upon the demand for steam by the stills and is controlled by a pressure governor on the exhaust side of the turbine. Speed is fixed by synchronous operation with the main power system. Operation of the stills on this exhaust steam has been quite satisfactory and is better than when the necessary pressure reduction takes place by throttling. Steam used by the stills does not fully load the turbine and provision is made to bring it up to capacity by passing more steam than the stills require and returning the excess exhaust to the low-pressure steam system to be used in the low-pressure cylinders of the turbines in the power plant.

At the Smelting Works a Westinghouse 800 kw. turbine operating at 150 lbs. pressure, condensing, is supplied with steam from waste heat boilers. Two melting furnaces discharge their hot gases through 800 and 396 hp. boilers respectively and two refining furnaces each have a 396 hp. boiler. Steam is thus available for power and heating purposes most of the time and two of the boilers can be fired independently if required. This is not ordinarily done for power generation because at times when steam from waste heat is not available power can be taken from the general system at less cost.

At the Ahmeek mill exhaust steam from the stamps goes to a 2,000 kw. low-pressure turbine, which may also be operated by high-pressure steam under governor control.

The 1929 records show the gross output of the system 132,999,500 kwh. That year is representative of recent operation without the new units at the Ahmeek mill which have been operating but a short time and under unfavorable load conditions. Power supplied by the various units was as shown in Table I.

The first item, 76 percent, represents output by fuel burned primarily for power generation. The other four items amounting to 24 percent of the total show the amount of power developed as a by-product of the milling and smelting operations. The units supplying by-product power necessarily operate to suit the work of the plants at which they are located. The Smelting Works and Still House turbines are not depended on to follow power demand, but they effect a substantial saving in coal, amounting to about 6,000 tons in 1929. The output of the turbines from stamp exhaust follows demand closely since it is about equal to the amount of power used for mill operation, and is always supplied when the mills work.

Steam stamp economy is not more than 10 or 15 percent better with condensing than with non-condensing operation. Experience at the Ahmeek mill showed an increase in steam consumption for the entire plant of 8,000 lbs. per hour when the change was made from operating stamps condensing, to operating them non-condensing and generating electricity with their exhaust steam. The exhaust steam turbine generated 2,000 kw. with an increase in steam consumption for the whole system of only 8,000 lbs. per hour, equilavent to 4 lbs. steam per kwh. produced.

New Power Plant—Ahmeek Mill

The Ahmeek Mill power plant, at this writing in operation only four weeks, was designed to generate 8,750 kw. and in addition, to supply 80,000 lbs. of steam per hour to the mill at 160 lbs. pressure to take the place of a boiler house in need of replacement.

The scheme adopted after careful consideration and in consultation with Stone & Webster Engineering Corporation, was to make steam at 425 lbs. pressure and 200 deg. superheat, to generate 7,500 kw. with boiler pressure steam direct to a condensing steam turbine unit, and 1,250 kw. from a high-pressure turbine generating unit acting as a reducing valve, and supplying steam at 160 lbs. pressure for the mill.

Freedom from interruption of service being of paramount importance, the boilers were installed of such size that although all three boilers are normally in use, two can carry the load.

Auxiliaries common to all three boilers are in the west end of the boiler house, and large enough to serve a fourth boiler. The east end of the building is constructed to provide possible extension for a fourth boiler should the future make such an addition desirable.

Buildings

Both the boiler house and the 7,500 kw. turbine room are of steel frame covered with galvanized corrugated iron over 2 in. matched wood sheathing with paper between. Steel sash with hinged windows and roof ventilators furnish light and ventilation. The roofs are of

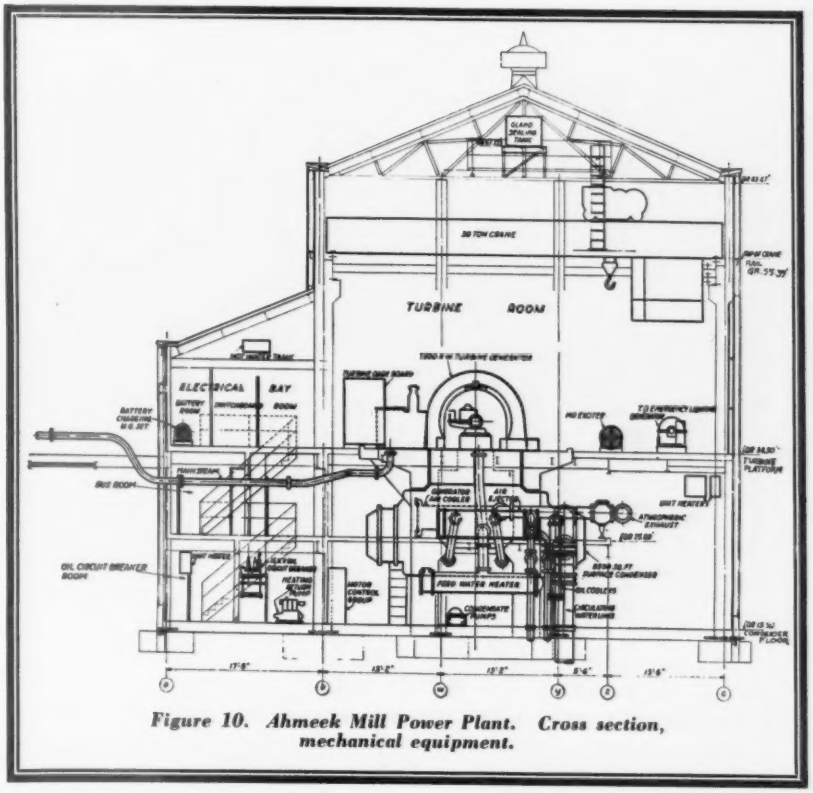


Figure 10. Ahmeek Mill Power Plant. Cross section, mechanical equipment.

precast gypsum supported on steel framing and covered with 4-ply composition roofing. The inside walls are finished with cement plaster on metal lath. Concrete piling supports all columns of buildings and conveyor as well as the foundations for turbines, boilers, and stack.

The turbine building is equipped with a traveling crane designed for a 30 ton normal load, and 47½ ton occasional load. The necessary heat in this building is provided by unit heaters, the condensate being returned by pumping to the turbine condensate pipe line.

Figure 3 gives the general layout of buildings and their relation to the mill.

Coal Handling

Existing coal bins which served the old boiler plant are utilized. They are incorporated in the concrete structure which supports the mill rock bins about 55 ft. above the ground. Coal is delivered in 22-ton cars over the company railroad and dumped from the rock service track through hoppers and chutes into the bins.

From the bins coal runs by gravity to a 24-in. apron conveyor traveling east 12 ft. per minute, which conveyor delivers the coal to a 26-in. by 24-in belt driven 2-roll crusher. The crusher drops the coal in sizes 1½ in. and smaller to a troughing belt conveyor traveling south. This belt is 170 ft. between centers, is 20 in. wide and inclined at an angle of 18 degrees. It in turn delivers the coal to another similar conveyor, 213 ft. centers, traveling west over the suspended bunkers in the boiler house and distributes the coal by means of a tank type tripper.

Boilers

The boiler house equipment is designed to furnish at normal load 180,000 lbs. of steam per hour at 425 lbs. pressure, 200 degrees superheat, corresponding to a temperature of 675 degrees. Deducting the steam used by auxiliaries, about one-half is for mill purposes and the other half for power generation.

There are three 8,955 sq. ft. Stirling, 4-drum boilers built for 450 lbs. pressure. Each is provided with superheater, soot blowers, 5,800 sq. ft. economizer and stoker. The stokers are the single ended 7-retort, 38-tuyere underfeed type with double roll clinker grinder and coal hopper agitator. The stokers are driven by individual steam turbines using boiler pressure steam and exhausting at about 5 lbs. pressure. They are equipped with hand and automatic speed regulators.

Each boiler has a turbine driven forced draft fan and a motor driven exhaust fan. This latter may be operated at either of two speeds, being coupled to two motors, one at either end, with speeds 710 and 460 r. p. m., respectively. The forced draft fan has a capacity of

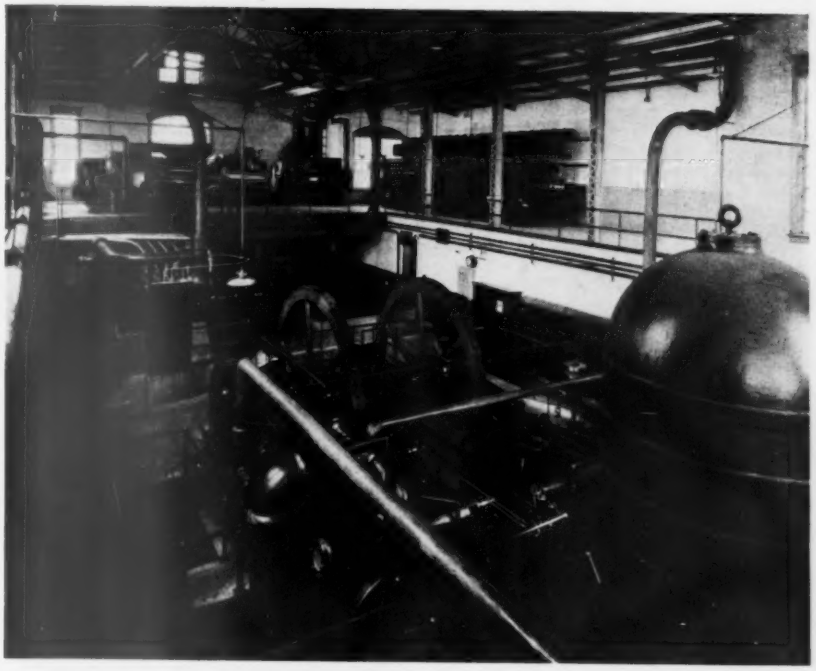


Figure 11. Ahmeek Mill Pump and Turbine Room. In the foreground is the 28,000-g. p. m. triple expansion reciprocating pump. On the same floor is the No. 7, 1,250-kw. reducing turbine unit and the by-pass reducing valves. In the rear is the No. 6 2,000-kw. exhaust steam turbine unit and the 2,300-volt switchboard.

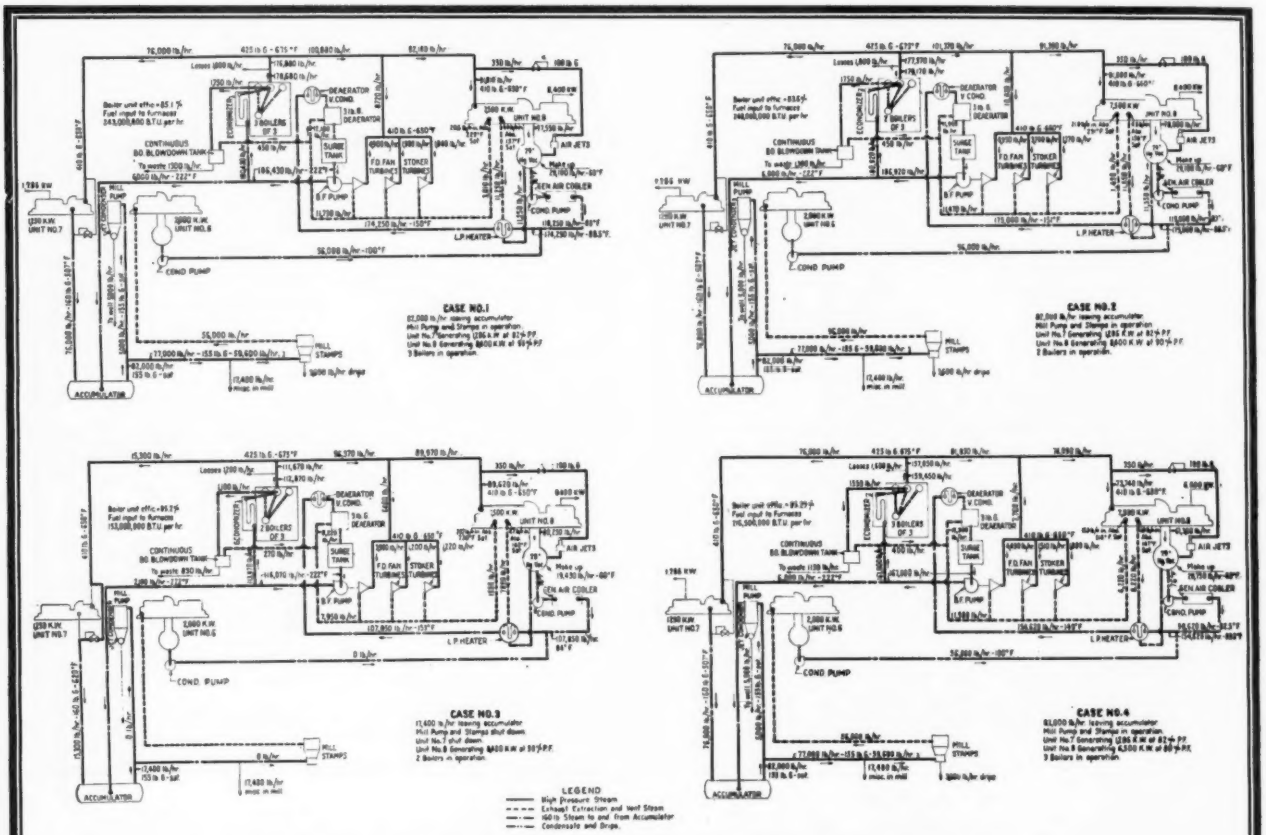


Figure 12. Heat Balance Diagram. Piping system, Power Plant, Ahmeek Mill.

40,000 c. f. m. against a static pressure of 9 in. of water. The exhaust fan capacity against the same head is 70,000 c. f. m. at 710 r. p. m. and 35,000 c. f. m. at 460 r. p. m. The exhaust fans deliver to the stack which is of reinforced concrete 12 ft. inside diameter and 175 ft. high.

Three 450 g. p. m. four-stage centrifugal boiler feed pumps direct connected to steam turbines and with duplicate water lines to economizers are provided, one pump having sufficient capacity to serve all three boilers at normal load of 180,000 lbs. of steam per hour.

Figure 4 gives a view of the main steam piping, stokers and control panels. *Figures 5* and *6* show the forced draft fans and feed pumps. *Figure 7* is a cross-section of the boiler house which gives the general layout.

Combustion Control

By means of combustion control equipment the boiler uptake draft and the quantities of air and fuel supplied to the furnace are adjusted to suit the load on the boilers. As the load varies, the pressure in the main steam header changes, slightly, actuating a master controller which changes the settings of the three induced draft controllers, one for each boiler. These in turn adjust the uptake draft dampers and the settings of the stoker turbine speed governors. Furnace pressure controllers actuated by the master controllers operate to hold constant furnace pressure by adjusting the forced draft dampers. This maintains main header pressure within 5 lbs. above or below normal. Compensating relays permit of adjusting the relative load on the different boilers at the will of the operator or of holding any boiler at a fixed load while the other boilers take the load changes.

Ash Handling

Airtight ash hoppers 12 ft. by 5 ft. by 8 ft. deep are built directly under the clinker grinders and reach to the boiler house floor which is at surface grade. Hand-operated water nozzles direct streams of water which sluice the ash through doors at the floor level into the hydraulic system. The hydraulic system consists of 560 ft. of 8-in. hard white cast-iron pipe and fittings laid under the boiler house floor in front of the ash hoppers, and continued in a concrete trough just below surface grade to the mill slime tailings pump. The sluicing nozzles located at proper points along the line of 8-in. pipe are supplied by a 600 g. p. m. motor driven pump, at 160 lbs. pressure. Fifteen tons of ash per hour can be handled.

7,500 Kw. Turbine

The 7,500-kw. unit operates at 1,500 r. p. m. and takes steam at 425 lbs. pressure and 650 degrees temperature. Three extraction nozzles are provided for heating the condensate and make-up water for boiler feed.

Condensing equipment consists of an Ingersoll Rand suspended two-pass, single compartment surface condenser, with 2-stage steam-jet air ejector. A horizontal double suction motor driven pump located in the mill pump house furnishes 11,000 g. p. m. circulating water required by the condenser. The 30,000 g. p. m. required by the Ahmeek mill is pumped from a well which is fed at its south end by gravity from Torch Lake. The 11,000 g. p. m. circulating pump takes its water from the south or inlet end of this well and when the mill pumps are running, which is 80 percent of the time, the circulating water discharge from the condenser returns to the north end of the well below water, to eliminate static head on the pump. The excess water required by the mill pumps over the amount taken by the circulating pump assures condensing water of lake temperature. When the mill pumps are not operating, the circulating water from the condenser is by-passed to Torch Lake.

Figures 8 and *9* show the turbine with its auxiliaries and switchboard, and *Figure 10* is a cross-section of the plant showing the general arrangement of turbines, auxiliaries and switchboard.

1,250 Kw. Turbo-Generator-Reducing Valves-De-Superheater

The Ahmeek mill requires 80,000 lbs. per hour of dry saturated steam. A 1,250-kw., back-pressure unit is used to reduce the boiler pressure of 425 lbs. to

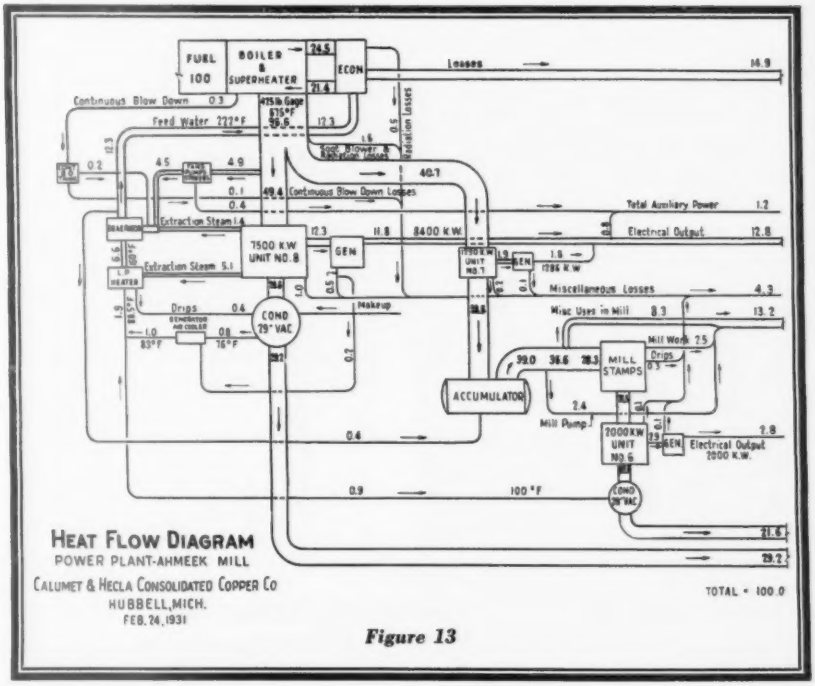


Figure 13

165 lbs. The turbine running at 4,500 r. p. m. operates the generator at 750 r. p. m. through reduction gears.

The exhaust steam from this turbine carries about 140 degrees of superheat. When the mill is shut down or if for any other reason the 1,250-kw. turbine is not running, the necessary steam for the mill is by-passed. Three by-passes are provided; one 4-in. with hand control, and one 4-in. and one 2-in. with regulators set to hold a constant pressure slightly under the back pressure of the turbine. When all the mill steam is taken through the by-passes, its superheat is 250 degrees as compared with 140 degrees in the turbine exhaust.

As the mill machinery is not adapted to the use of superheated steam, it is necessary to use a de-superheater to give dry saturated steam for mill purposes. This is of the accumulator type, 8 ft. in diameter by 30 ft. long. It requires for de-superheating approximately 6,500 lbs. of water per hour when the turbine furnishes the steam and about 12,000 lbs. per hour when steam is taken through the by-pass system. About 3,000 lbs. per hour of the de-superheating water returns by gravity to the accumulator as condensates from steam stamp re-heaters and main steam lines.

Figure 11 shows the turbine together with the by-pass equipment. It also shows the exhaust steam turbine and 2,300-volt switchboard as well as the Nordberg 28,000 g. p. m. mill pump.

Feed Water

Under normal conditions the boiler feed water is made up of approximately 50 percent condensate from the 7,500-kw. unit, 35 percent from the 2,000-kw. exhaust steam unit, and 15 percent Lake Superior make-up water.

Water is pumped from Lake Superior for boiler feed and domestic purposes. To protect against lengthy interruption of this service, occasionally of 24 hours duration, a reservoir is provided at a convenient elevation a few hundred feet from the boiler house. It has a capacity of 350,000 gallons, sufficient to take care of make-up for 96 hours. A float valve on the inlet keeps the reservoir full.

The make-up water enters the condenser of the 7,500 kw. turbine and is pumped with the condensate through the generator air cooler, adding a few degrees to the water temperature. The condensate from the condenser of the 2,000 kw. turbine then joins the water coming from the air cooler and passes through a closed heater supplied with steam at 2 to 3 lbs. absolute from an extraction nozzle on the 7,500 kw. turbine. This feed water now at a temperature of 125 deg. F. passes through a deaërator vent condenser and a vertical cylindrical deaërating heater in the boiler house. The steam for the deaërating heater consists of the exhaust from the turbines driving the boiler feed pumps, forced draft fans, and stokers, supplemented by additional steam at 3 to 6 lbs. gauge pressure from an extraction nozzle on the 7,500 kw. turbine. The water leaving this equipment at 220 deg. flows to a surge tank and then to the boiler feed pumps from which it passes through the economizers, entering the boilers at a temperature of 330 deg.

A 10,000-gal. surge tank is provided with an upper float valve which controls the flow of make-up water entering the condenser of the 7,500 kw. unit by admitting just the amount necessary to maintain the surge tank water level below the overflow point. A second float valve about 4 ft. lower than the first provides for the control of make-up water direct to the deaërating heater when the 7,500 kw. turbine is idle, or if for any other reason that source of feed water fails. In this case the condensate from the 2,000 kw. turbine also is passed to the deaërating heater instead of entering the feed water system ahead of the closed heater in the turbine room.

Feed Water Treatment

The steam for the 2,000 kw. turbine being the exhaust from the stamps, the condensate from this turbine contains lubricating oil. This condensate represents 35 percent of the total feed water. Two pressure type sand filters with coagulent and alkali feeding equipment are used to remove this oil before it joins the rest of the boiler feed water.

To provide for the desired limitation of the boiler water concentration, a continuous blow-down pipe leading to a flash tank is placed in the middle upper drum of each boiler. The major part of the heat in the water so blown down is reclaimed by the steam flashing to the deaërating heater.

The Hall Laboratories system is used to control the chemical composition of the boiler water and to prevent the precipitation of dissolved solids in a form which would cause adherent scale on the boiler surfaces. Phosphate, which is fed direct to the boilers, by combining with the scale-forming elements in the feed water, forms finely divided insoluble phosphates which remain in suspension and are removed by blow-down. As this phosphate reduces alkalinity, caustic soda is added to maintain the proper basic condition of the boiler water to protect against corrosion, foaming, and caustic embrittlement. Sodium sulphate, which is fed into the surge tank, tends toward the same result. These measures, together with the deaërating heater, assure protection against impure water.

Instruments

Recording and indicating meters are used to furnish information for efficient operation of boilers and turbines as well as to determine the proper distribution of steam and power costs.

Counters on the stoker retort driveshafts, when calibrated in service over a period of months, will permit of determining coal consumption rate for any boiler. This, together with steam flow integrating meters for each boiler as well as for total plant load, makes it possible to follow daily the plant or individual boiler efficiency.

Figure 12 gives the heat balance with four different sets of conditions as to mill and electrical load, and *Figure 13* is the heat flow diagram under full load.

Power Costs

Without interest and depreciation charges, exhaust steam turbine costs are under .20 cents per kwh. It is too early to give the power costs of the new turbines, but it is expected that these will be under .20 cents per kwh. for the 1,250 kw. unit, and under .33 cents per kwh. for the 7,500 kw. unit.

Stone & Webster Engineering Corporation started field work on this plant July 1, 1930, and seven months later, on February 1 of this year, the plant was in full service.

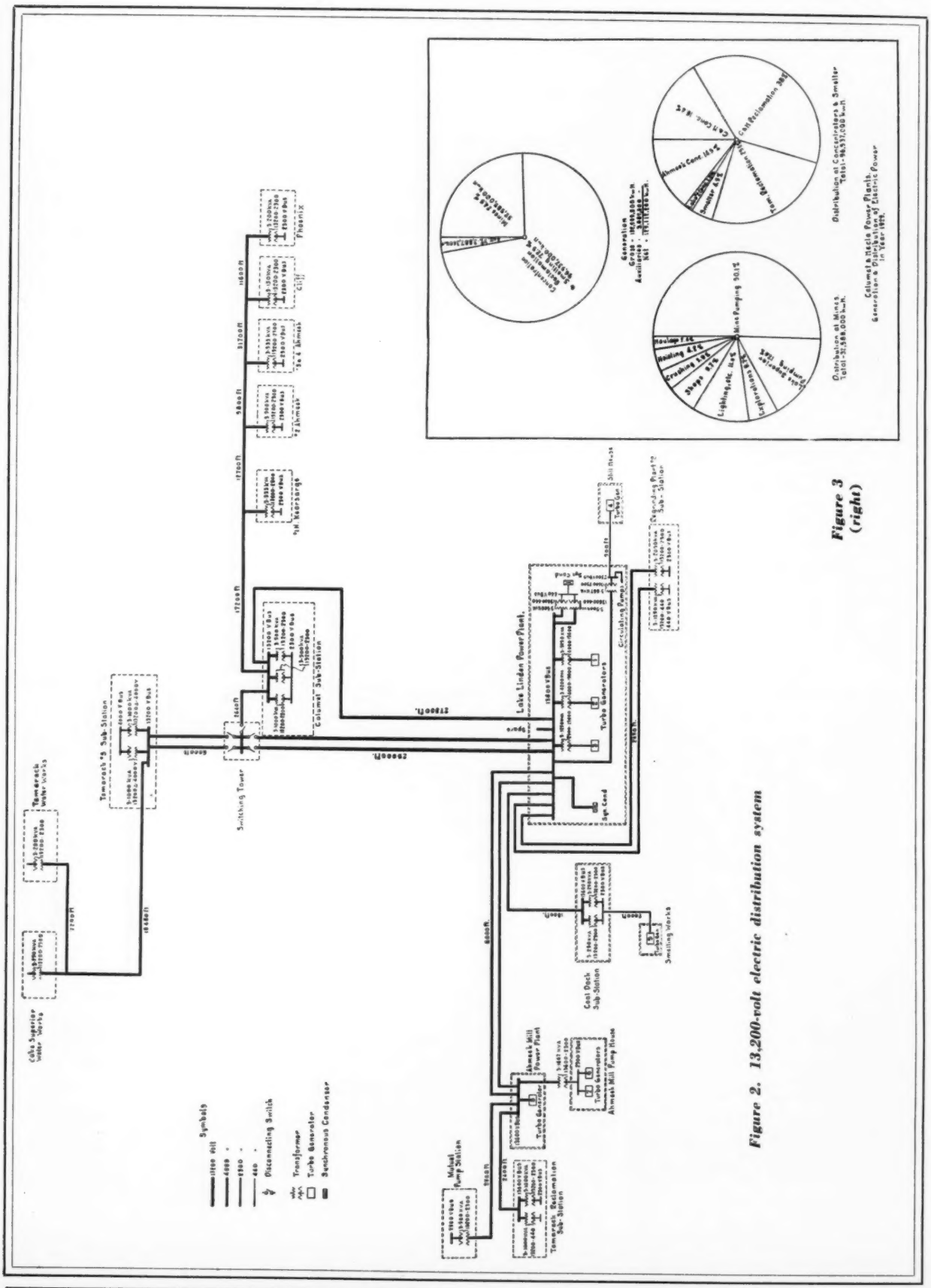


Figure 3 (right)

Figure 2. 13,200-volt electric distribution system

CALUMET AND HECLA CONSOLIDATED COPPER COMPANY

Figure 1. Lake Linden power plant arbor

Electric POWER DISTRIBUTION

By Frederick N. Bosson*

THE first lighting plant installed by the Calumet and Hecla Company was located in the Calumet mill at Lake Linden, and went into commission in May, 1878. It consisted of a Siemens a. c. generator and exciter and 24 arc lamps. This apparatus is now in the Engineering Museum in New York.

In 1881 a Brush arc dynamo, serial No. 26, and eight 4,000-c. p. lamps were installed at the mine for surface lighting. They were mounted on two tall masts and were put in commission on the night of July 4 as part of the day's celebration. Following this, two arc-lighting dynamos of 35 2,000-c. p. lamp capacity were installed and were used in the interior lighting of buildings. In 1892 the electric station at the mine was put in commission, which included incandescent machines and power for pumps, as noted in the article on underground power distribution.

In 1895 an electric plant was started at the Calumet and Hecla mills, which consisted of 3 a. c. lighting machines and three Brush arc machines. In 1901 a 300-kw., 25-cycle generator was purchased for the operation of the pumps that were installed in No. 7 shaft; but the real beginning of the present power system dates from 1902 when two 1,000-kw. generators, engine-driven, generating at 440 volts, three-phase, 25-cycles, were started for the mill electrification. the mine and mills were connected with transmission lines in 1906 after three 2,000-kw., 13,200-volt, engine-driven generators were installed.

At present there are two main generating stations, one at the Calumet and Hecla mills at Lake Linden and the other at the Ahmeek mill at Hubbell. These two stations operate in parallel, the two 13,600-volt buses being tied together by two 250,000 c. m. tie lines. The other turbo generators feed into the 13,600-volt system through transformers and feeders, making up the total generating capacity of 40,000 kva. At the Lake Linden plant there are eight outgoing feeders, including the two tie lines between the two generating stations. These feeders go out of the building overhead into an arbor from which they diverge. (See *Figure 1.*) The arbor is laid out so that circuits can be easily interchanged. At the Ahmeek station there are two incoming tie lines and two outgoing feeders. These are carried underground by three-conductor cables from a distributing tower located about 200 ft. from the station.

All power from the main stations is distributed at 13,600 volts, 25 cycles, three-phase, with the exception of a small amount of power for auxiliary use and the original 440-volt zone at the Calumet and Hecla mills. The 13,600-volt distribution is carried on wood poles and cross arms. Pin-type insulators of 23,000-volt working pressure are used to carry the wire on a 3-ft. delta and deliver power to 13 substations located at load centers. (See the diagram, *Figure 2.*)

Secondary distribution is done at 2,300 volts from all substations with the exception of No. 5 Tamarack substation, which delivers at 4,000 Y, and the regrinding plant and Tamarack reclamation substations where both 2,300 and 440 volts are distributed. The transformer capacity at the distributing centers aggregates 45,150 kva., and the total connected a. c. motor load is 53,365 hp. with a total of 895 a. c. motors, the largest being 1,250 hp. With a few exceptions, all surface motors of 50 hp. and above are 2,300 volts; those below 50 hp. are 440 volts. All motors used underground are 440 volts with the exception of the 5 hp. and smaller motors, which are usually wound for 110 volts. The company also has a total of 87 d. c. generators aggregating 4,150 kw. that furnish power to 260 direct current motors of 4,375 hp. capacity.

Lighting throughout the mill and the main circuit at the mine is done at 60 cycles. This current is obtained by frequency changers of a combined capacity of 1,500 kw. The balance of the lighting is 25 cycles.

On the opposite page are three circle diagrams showing the total power generated and distributed for the year 1929. (*Figure 3.*)

* Electrical Engineer.

Figure 4. Typical substation for power distribution, at Ahmeek Mine

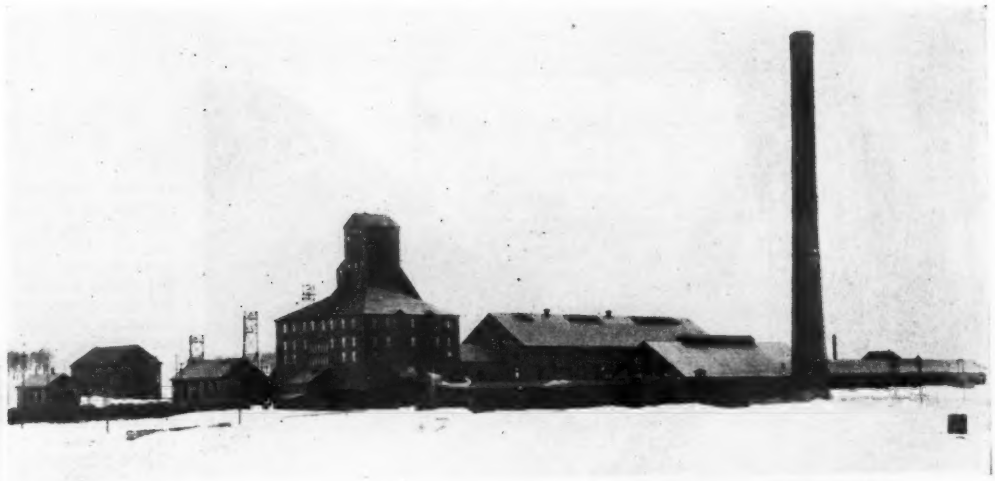


Figure 1. Plant at Red Jacket shaft.

Figure 2 (above) Plant at North Ahmeek, No. 3 and 4 shaft

Figure 3. Rock house at Ahmeek No. 2 shaft

Figure 4 (below) Pattern shop, foundry and smith shop at Calumet

CALUMET AND HECLA CONSOLIDATED COPPER COMPANY

MINE SURFACE PLANTS

By H. E. Williams*

THE mine surface plants of the Calumet and Hecla Consolidated Copper Company comprise hoisting, compressing, pumping, and boiler plants, which are described in the paper entitled "Mining Operations—Hoisting Equipment and Methods"; and shaft rockhouses, miners' change-houses, and shops, which are described in this paper.

Shaft Rockhouses

All the shafts of the Calumet and Hecla are located in the lodes except the Red Jacket shaft of the Calumet conglomerate, which is vertical, and Nos. 3 and 4 Ahmeek of the Kearsarge amygdaloid, which are twin diverging shafts sunk through the hanging-wall at an angle of 80 degrees to the horizontal. Each shaft is equipped with a rockhouse arranged for crushing, storing and shipping ore.

These rockhouses consist of a large ore bin or bins provided with chutes for filling ore cars, and constructed to support suitable crushing machinery, skip dumps and head sheaves. The shaft collar is protected from the elements by a building arranged for handling mine supplies, and at all inclined shafts drop switches for transferring skips and man-cars from surface to shaft tracks are provided.

As the ore mined from all producing lodes is usually in large pieces and contains occasional masses of native copper, the crushing machinery must be of heavy construction and designed so that these masses of copper can be easily and quickly removed. Jaw crushers of the Blake type successfully meet these requirements and are exclusively used in this district.

The more important rockhouses of this company are equipped with 24-in. by 48-in. Blake type crushers which are of special Calumet and Hecla design and are built in the company shops. (*Figure 5.*) The frame is a unit grey iron casting, specially ribbed for strength and to accommodate reinforcing rods. Each side of the frame is reinforced by two 5-in. diameter straight longitudinal rods, the front end by three and the rear end by two 4-in. diameter curved rods. These rods are heated to a cherry red, placed in position in the frame and the nuts tightened, thus setting up an initial compression in the frame which considerably increases its total tensile strength. To prevent excessive vertical vibration of shafthouse floors, due to the operation of the crushers, the cast-iron pitman is spring suspended from cast-iron yokes supported on the crusher frame. Jaw and head block liners are of manganese steel. This crusher consumes from 0.25 to 0.30 hp. hours per ton of ore, and crushes at the rate of approximately three tons per minute, including fine ore which passes through the grizzlies. Each crusher is driven by one 18-in. belt, runs at 175 to 180 r. p. m., weighs about 40 tons fully equipped, and crushes to 4-in. size.

Rockhouse at Red Jacket Shaft

At the vertical Red Jacket shaft (*Figure 1*) the rockhouse is a high steel structure, divided into two rectangular ore bins each 40 ft. by 81 ft. 6 in. At present all ore handling is confined to the east bin which is served by two railroad tracks, one for ore and the other for waste. Cast-iron chutes of the duplex gate type, individually operated, are placed so as to load across the cars. Ore is loaded into 40-ton hopper bottom cars and waste rock into side dumpers.

The shaft opening is covered by a steel head frame which connects the two ore bins and supports the six head sheaves. The sheaves for the ore-hoist are 16 ft. in diameter and those for the man-hoist 10 ft. in diameter, the center of the highest sheaves being located 109 ft. 9 in. above foundations.

Ore is hoisted in Kimberly skips of 7½-tons capacity. The skip dumps over a fixed apron inclined 33 degrees to the horizontal onto a curved steel grizzly (*Figure 6*), made up of steel bars 4 in. in diameter set 7½-in. centers. This grizzly is pivoted at its lower end next to the crusher and is provided with hoisting beam and tackle at its upper end. After the skip is dumped, the grizzly is tilted to feed the coarse rock into a 24-in. by 48-in. Calumet crusher. This is accomplished by means of a power winch operated by "V" groove friction wheels, belt-driven from the main shaft. A similar winch handles large pieces of ore and also operates a timber bumper which is set across the mouth of the crusher to prevent ore entering when the skip is dumping.

Waste rock is hand-picked from the grizzly and is crushed in a 13-in. by 30-in. Blake type crusher, discharging into the wasterock section of the bin.

To care for occasional skip loads of waste rock, 2½-in. extra heavy bent pipes are placed between the grizzly bars to prevent fine waste rock falling into the copper ore bin. A small carriage with inclined bottom is arranged to slide under the opening of the ore crusher and chute the crushed waste rock into the waste bin. Power for operating the crushers and tilting aprons is supplied by a 100-hp. induction motor.

Rockhouse at Nos. 3 and 4 Ahmeek Shafts

Nos. 3 and 4 Ahmeek (*Figure 2*) are diverging shafts sunk at an angle of 80 degrees to the horizontal, the angle between their horizontal projections being 41 degrees, 50 minutes. The center lines of their inside compartments are 22 ft. 4 in. apart at the collar and 12 ft. 7 in. apart at the skip dump, 77 ft. 3 in. above the collar. The mouths of the near skips are 7 ft. 6 in. centers when dumping.

The shaft collars are covered by a steel building 60 ft. by 80 ft. 6 in., provided with transfer tables at each shaft for shifting skips and cars from track to track, and with drop switches equipped with back runners for transferring equipment from skip road to transfer table. (*Figure 7.*) A transverse trolley beam is provided for transferring drills into the drill shop and mass copper to a loading platform outside the collar house.

The shaft rockhouse contains a cylindrical steel bin 48 ft. in diameter by 45 ft. 6 in. high, holding 2,500 tons of ore. This is supported on two heavy, crescent-shaped concrete foundations located outside of the two railroad tracks, and on a steel bent between the tracks. All foundations are supported on a circular reinforced concrete mat 68 ft. in diameter by 5 ft. thick.

Steel chutes of the duplex door type are set in the bottom of the bin. These chutes, which load the 50-ton hopper bottom cars longitudinally, are operated from a pulpit arranged so that one man controls the filling of cars on both tracks. A waste rock bin holding 300 tons of rock is located under the skip tracks.

* Chief Draftsman.

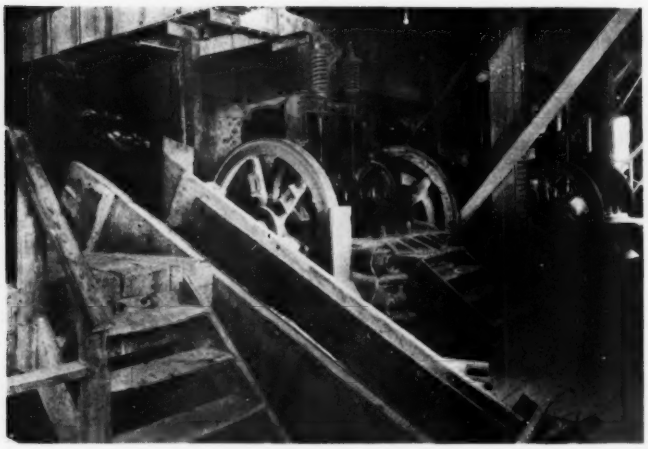


Figure 5. 24" x 48" Calumet rock crushers in Red Jacket shaft house

The crusher floor girders are supported by the cylindrical bin wall and a heavy central steel column. The four 12-ft. diameter head sheaves, located 120 ft. above the collar, are carried on heavy steel girders supported on columns.

As the hoisting engines, located on the hanging-wall side, are housed under one roof, the head sheaves are placed on the hanging side of the skip tracks and are tipped and skewed to suit the lead of the ropes. The hoisting rope lines are carried on 4-ft. diameter idler sheaves, supported by three steel sheave stands designed to be self-supporting transversely but supported longitudinally by wire guys attached to concrete anchors.

As the shafts are steep, skip dumps are of the controlled type. The two skips in each shaft discharge onto a common apron, trapezoidal in plan, provided with a solid curved bottom pivoted at its lower end and arranged with hoisting beam for raising when feeding ore into the crushers. These aprons are built of steel, their bottoms being lined with removable manganese steel plates. They are also raised when waste rock is dumped from the skips into the waste rock bin located beneath the skip tracks. Each apron discharges ore through a chute into a 24-in. by 48-in. Calumet crusher.

Winches similar to those in the Red Jacket shafthouse are provided for hoisting the feeding aprons and also for handling large pieces of ore. Machinery is belt-driven from the main shaft, power being supplied by a 150-hp. induction motor.

Rockhouses for Shafts in Lode

Due to the comparatively flat dip of the lodes, the rock and collar houses are separate buildings connected by an inclined skip runway structure. The rockhouse at Ahmeek No. 2, Ahmeek, built in 1915, is typical for shafts of this kind. (*Figure 3.*) It has a cylindrical steel bin 40 ft. in diameter by 38 ft. high, holding 1,800 tons of ore. This is supported on two heavy crescent-shaped concrete foundations and on a steel bent located between the two loading tracks. The center of the columns of this bent are extended to support the main girder in the crusher floor. To clear obstructing buildings, the loading tracks extend diagonally under the copper rock bin, thus skewing the foundation piers and the steel bent with reference to the upper structure. Rockhouse equipment and practice are, in general, similar to that already described.

Miners' Change Houses

Miners' change houses are located in close proximity to all operating shafts. While some of these at the older locations are wooden buildings, at the newer shafts they are of concrete, brick and steel construction. The basement is arranged for storing light mine supplies, and the main floor is divided into a large miners' change room, first-aid room, and offices for the captains, shift-bosses, and timekeepers. All partitions are cement plaster on hi-rib, with floors pitched toward drains to facilitate washing with a hose. (*Figure 8.*)

Figure 6. Crusher feeding apron with grizzlies at Red Jacket shaft house

Individual steel lockers, arranged with separate boot lockers and provided with seats, are arranged in transverse bays, nine lockers in a row. The main longitudinal aisle contains a run of white enameled wash troughs provided with hot and cold water taps. Toilet facilities and showers are provided at one end of the change room.

The change room and offices are light and airy and are steam heated by overhead coils specially arranged for drying damp clothing. The later change houses are 42 ft. 6 in. wide by 94 ft. 6 in. long, and accommodate 252 workmen in addition to captains and shift-bosses.

Shops

The main shops are located at Calumet (*Figure 4*) in close proximity to the workings on the Calumet conglomerate and Osceola amygdaloid lodes. These include the machine, smith, drill sharpening, boiler, carpenter, car repair, structural steel and paint shops; wedge mill, foundry, and pattern shop. Smaller branch shops for light repairs are located at outlying mines, concentrators and smelter.

Among the major articles of equipment manufactured in these shops for use at mines, concentrators, railroad and smelter are 24-in. by 48-in. Calumet ore crushers, 38-ft. diameter Clark casting machine and Bosh conveyor, 25-ft. diameter fly wheels, 8-ft. conical ball mills, 2½-in. to 16-in. centrifugal sand pumps, small mine hoists, etc.

The machine shop is a rectangular stone building 53 ft. wide by 416 ft. 9 in. long, with a lean-to 17 ft. wide by 230 ft. long. The main bay is served by a 25-ton traveling crane with runway 315 ft. long. This runway covers the erecting floor and the heavier machine tools, the lighter tools being grouped beyond.

The smith shop is a stone building with a main bay 56 ft. wide by 240 ft. long, provided with a 10-ton electric crane for heavy repairs, and an ell 46 ft. by 230 ft. It houses necessary tools for building and repairing skips, tram cars, water bailers, and the general run of mine, smelter, and concentrator machinery.

The foundry is a brick building 120 ft. wide by 210 ft. long, with a 50-ft. main bay served by two 15-ton traveling cranes, while the side bays are served by lighter cranes. It is equipped with one 48-in. and one 36-in. Whiting cupola, two core ovens, moulding machines, etc. As some of the principal products are stamp shoes and other white iron castings, special equipment has been provided for this class of work. A 5-ton electric crane on a steel runway 36 ft. span by 264 ft. long serves the foundry yard.

The pattern shop is a brick building 75 ft. by 105 ft., equipped with modern pattern-making machinery. The patterns are stored in three large semi-fireproof pattern storages.

The wood working shops are in charge of the construction department which directs the work of carpenters, masons, painters, structural steel workers, surface laborers, teams, and trucks. It builds and repairs all structures at the mines, concentrators and smelter; repairs railroad cars, constructs and maintains all roads and surface work. and operates the carpenter, car repair, paint, and structural steel shops, and wedge mill.

The carpenter shop is a frame building 202 ft. by 68 ft., two stories high. It is equipped with wood-working ma-

chinery for manufacturing mine supplies and repairing parts for mine buildings and equipment. All machines are connected with a central exhaust system for handling shavings and sawdust.

About 1,000,000 ft. B. M. of lumber, 11,000 mine rollers, and 25,000 ft. B. M. of sheave fillings are manufactured per year.

The wedge mill is a steel building 56 ft. by 52 ft., provided with cut-off saw, wedge machine, conveyors, and other machinery for manufacturing hardwood mine wedges. The adjacent timber storage yard is provided with an overhead cableway for unloading and handling timber to the wedge mill. About 650,000 ft. B. M. is manufactured into wedges per year.

Drill Sharpening Shops

The Calumet and Hecla uses two processes for sharpening drills, the Morrison process at Calumet for drills used on the Calumet conglomerate and Osceola amygdaloid lodes, and the Ingersoll - Leyner process at Centennial, Kearsarge, and Ahmeek for drills used on the Kearsarge lode.

In the Morrison process sharpening is divided into seven operations: heating, sharpening, upsetting, fluting, sizing, reheating and tempering. (*Figure 9.*) The shop for this process contains two sets of machines, one arranged for sharpening cross-bits and the other for chisel bits, and each is capable of sharpening 2,700 drills per 9-hour day.

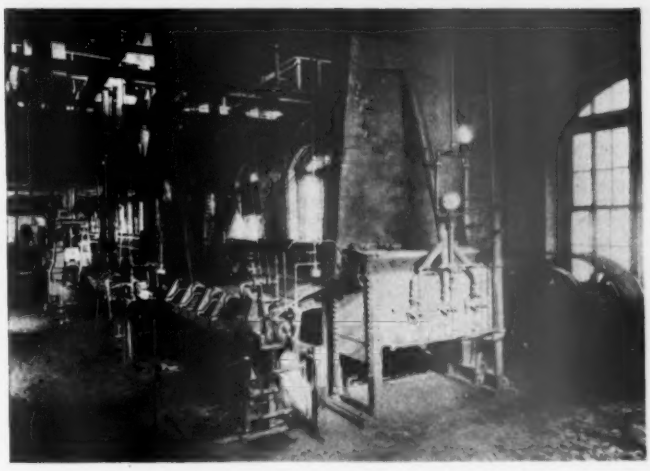


Figure 9. Morrison drill sharpening machines

The receiving department of the drill shop is equipped with an electric traveling crane for removing the drill boxes from the trucks to the inspection department. Here crooked and broken drills are sorted out, and the dull straight drills placed by hand on the upper section of a belt conveyor. From this they are transferred by hand to a cross - chain conveyor at the heating furnace, the bits projecting beyond the edge of the conveyor.

An electrically operated counter automatically records each drill as it passes through the heating furnace. The conveyor carries the bit ends through the furnace with a rotating motion and delivers them to the pneumatic drill sharpener which works the steel out from the center toward the outer edge of the bit. From the sharpener they are conveyed on a longitudinal chain to the pneumatic upsetter which restores the diameter of the drill. From the upsetter a similar longitudinal chain carries them to the fluter. This is an 800-lb. steam hammer which straightens the vanes and reduces them to standard thickness. From the fluter they are conveyed in a similar manner to the mechanical sizer which automatically sizes the bit according to the drill length. As the bits are now too cold for tempering, they pass through a reheating furnace on a cross-conveyor of the same type as is used at the heating furnace. This drops the drills into a water-tempering bath from which they are discharged by a chain conveyor onto the return section of the belt conveyor. On this they are carried to the receiving department where they are discharged by hand into the drill boxes.

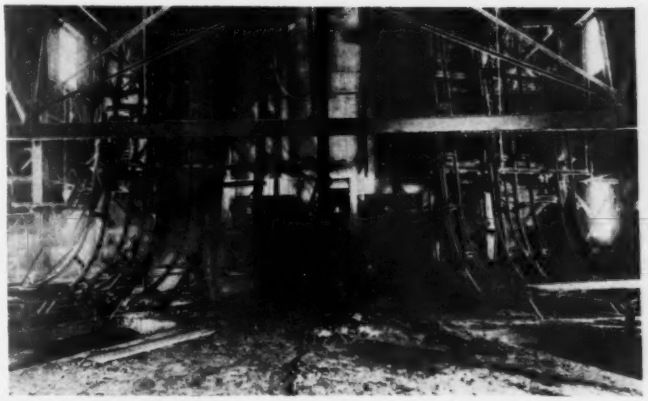


Figure 7. Drop switches at No. 3 and 4 Ahmeek shafts

The machines are belt-driven from overhead shafting by a 50-hp. motor. The compressed air is furnished by an Ingersoll-Rand duplex belt-driven compressor. Both heating and tempering furnaces are oil fired. The air for combustion is preheated by passing through flues in the furnace stacks.

The drill shops at Centennial, Kearsarge and Ahmeek are located adjacent to the collar houses at each shaft. Drills are conveyed in steel boxes from the skip to the shop by a chain block and trolley running on an overhead I-beam or in hand-pushed cars. These shops, which are equipped with No. 5 Leyner drill sharpeners, heating and tempering furnaces, are arranged in the conventional manner.

PURCHASING DEPARTMENT

(*From page 552*)

counts, these invoices are sent to the supply department for endorsement before payment is made. Through the medium of the triplicate copy of the invoice the supply department has already "checked" in the material, so this endorsement is a simple matter, and the original is then returned to the accounting department for payment and permanent record. When paid, the accounting department notes on each invoice the date paid and check number and it is sent to the general manager for approval before check is mailed. Thus, complete information relating to price, extensions, discount, receipt of material and payment is shown on each invoice, and each department is responsible for its particular part in the transaction. This procedure provides against the possibility of an invoice being paid twice or of two bills being passed for the same goods.

Purchasing Department Procedure

By E. C. Messner*

THE purchasing department begins to function upon receipt of a requisition signed by the head of a department requiring supplies, material or equipment.

For the purchase of minor supplies and standard items of current stock, no further authorization is required; but for machinery and equipment involving a considerable expenditure, the approval of the general manager is necessary before the order is placed. When the purchase of such equipment is contemplated, specifications are drawn up and inquiries sent out requesting information covering the essential points, such as construction, price, delivery, etc., together with request for manufacturer's recommendations. This information is tabulated and carefully analyzed by the purchasing department and the heads of the departments interested. After complete discussion and agreement, the company offering the most satisfactory proposal is awarded the order. The advice of the heads of departments and engineers in connection with such purchases, and in all matters requiring technical knowledge, is a necessary and valuable factor in the functioning of the purchasing department.

Relations with Vendors

Good will is a recognized necessary asset in any line of business, and this is particularly true in the purchasing field. The good will of salesmen and the firms they represent is of vital importance to the purchasing department, and it is the policy of this company to gain and retain good will by adherence to the highest standards of business ethics and courtesy in dealing with vendors. All conditions embodied in the purchase agreement are most carefully observed and adhered to; payments are made promptly as bills become due, and cash discounts deducted only when within the time limits indicated on the invoice or stated on the order. The value of good will has frequently been evidenced by extraordinary effort on the part of vendors to give special attention to emergency orders and to give advice regarding price trends as well as other valuable information.

As a general thing salesmen contact the purchasing department first and are promptly interviewed by the purchasing agent or his assistant. Owing to the large variety of equipment and material required, however, it is often necessary for them to interview members of the engineering or production staff. Arrangements for such interviews are made through the purchasing department.

Contacts With Other Departments

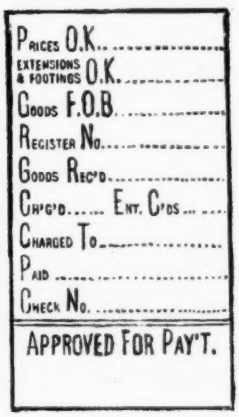
In view of the fact that the production departments are held responsible for economical operations, it is their privilege and right to demand that materials purchased shall be adapted to economical and efficient production. It is the aim of the purchasing department to render to the production staff all possible aid in attaining this end. In like manner, the rights of the purchasing department are understood and respected by the other departments of the company; one of the most important considerations is that all purchase negotiations should begin and end in the purchasing department.

Every effort is made to cooperate with the engineering departments in securing information of a technical nature. In special instances, engineers negotiate directly with the vendor for engineering information and data or for preliminary prices that may be used for estimating purposes. This, however, is done after consulting with the purchasing department. All bulletins of a technical nature are promptly forwarded to the proper individuals when received.

A live catalogue file is maintained for the use of all departments of the company.

Purchase Orders

Purchase orders are issued in quadruplicate; the original is sent to the vendor, the duplicate is kept by the purchasing department and two copies are for the supply department. A return postal card is attached to the original on which the vendor acknowledges receipt of the order and gives probable shipping date. When this card is returned the information is noted on the purchasing department's copy of the order and it is then sent to the supply department. From this point on, the supply department follows up the order to ensure shipment on the date promised.



The number of purchase orders issued in a year is about 8,500, and the total amount of purchases, excluding coal which is purchased through the eastern office of the company, is over $3,000,000.

Invoices

All invoices covering purchases together with original bill of lading and other papers bearing on the shipment are mailed in triplicate direct to the purchasing department. When received the invoice is stamped as shown in the accompanying illustration.

The triplicate copy and shipping papers are sent to the supply department, thus informing the latter at once as to what materials are enroute; the original and duplicate copies of the invoice are matched with the order and turned over to the invoice clerk for checking. Extensions are verified, prices checked and cash discount deducted in accordance with the terms; all of which, together with a notation showing that prices are "delivered" or otherwise, are endorsed on the order and on both copies of the invoice. To enable the supply department to complete its records without loss of time, the duplicate copy is forwarded to it for use in recording and pricing the material. The original copy of the invoice is sent to the accounting department, for proper record in the bills payable register, and placed in line for payment. As it is not customary to pay any invoices until the goods have been received, except to take advantage of cash dis- (*Continued on page* 551)

* Purchasing Agent.

Exterior of No. 1 Warehouse

By
P. J. McClelland*

Supply Department Procedure

THE function of the supply department, as its name implies, is to furnish supplies to the operating departments of the company in the varied operations of mining, milling, reclaiming and smelting copper.

The aim is to carry a minimum of stock consistent with good service, in order to conserve capital investment, particularly in such equipment as may become valueless through obsolescence. To accomplish this the stock-number and card system showing perpetual inventory is used. Every article carried in stock is known by a number that is given at the time the article is received and follows it through to delivery; an exception is made of coal which, because of quantity and method of handling, is carried by the supply department in a separate account. The entire situation is modified further by another important factor brought about by transportation considerations. It is advantageous to requisition sufficient material to be shipped via the Great Lakes to last through the winter season, so that under certain conditions our minimum stock rule is set aside in order to save transportation charges.

The supply department has a personnel of 30 people whose duty it is to care for all the requisitioning, receiving and handling of supplies, with the exception of coal.

The work is divided under the following heads:

Requisitions on the purchasing department.
Receiving and inspection of material.
Placing material in storage.
Checking office copy of purchase order and passing invoices.
Stock keeping system.
Materials distribution.
Manufactured stock.
Miscellaneous.

* Supply Clerk.

Requisitioning Stock

Requisitions on the purchasing department are of two types: special material and stock material. They show the destination of the material ordered, the routing, the firm name from whom last shipment was received, or the firm with whom the order is to be placed, and any other information of value to the purchasing agent.

When the order is placed, two copies are given the supply clerk and the stock number is immediately posted in the case of stock orders. One copy becomes the office record on which is posted the invoice, the receipt of the material (thus reconciling the invoice with the material received) and also any transportation charges; it, therefore, serves as a complete record of all information pertaining to the order. The other copy becomes the record of the receiving clerk.

The supply department assumes all responsibility for tracing the material to destination, checking on receipt for quantity and quality and, in case of special orders, delivering to the department from which the order originated and charging same to the account designated.

Receiving and Inspecting Material

Upon receipt of the material, the receiving clerk, after a careful examination and check, tabulates the necessary information on his copy of the order, showing the amount received, the date and manner received; he attaches a copy of the express or freight bill from which the transportation charges are posted to the office copy, together with other information pertaining thereto such as, "over," "short," and "damage claims." These are taken up with the firm supplying the material, or the transportation company, and carried to completion, either through replacement of material or credit to the supply account. The material is then turned over to the storekeeper for proper storage, the receiving clerk furnishing him with the stock number that he obtains from his copy of the purchase order. From the receiving clerk's copy of the purchase order the office records are posted and the original invoices checked "goods received" and returned to the accounting department for payment.

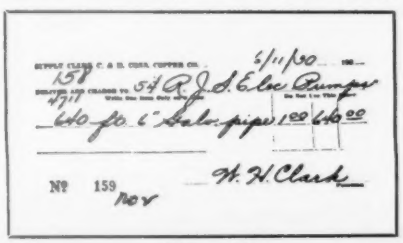


Figure 1

Stock Keeping System

Orders covering stock material are passed to the posting clerk who makes the necessary receipt on a stock card (size 11 in. by 17½ in. as represented in illustration *No. 2*), which is kept in a large fireproof sectional card case containing 10,000 cards. The card shows the purchase order number, the date of issue, a description of the article and the name of the firm furnishing the material, and the date and the amount received; also when the charge order is posted it shows the date of issue, a description of the article, the price and amount charged and shows the actual deduction and balance of stock.

In addition to the stock number and card system, and to aid in maintaining minimum stock, a "low" and "all out" card system is used. This information is furnished by the storekeeper and applies where unusual demands are made on the stock or advance information is received from a department regarding unusual requirements.

Stock shelves in No. 1 Warehouse

Interior of No. 1 Warehouse

After all information has been entered on the office copy of the purchase order, a price is calculated for each unit item made up from the invoices, transportation charges and handling cost, and is posted to the stock card for the pricing clerk's information. The method of pricing is to average the balance of old stock on hand with the new goods received, so that the value of the stock on hand may be obtained at any period.

Direct withdrawals of stock are made only on charge orders as illustrated in *Figure 1*. Departments are furnished with these orders in book form in duplicate. Orders state the account to which the item is charged and note the quantity and description of material. The original copy is presented to the storekeeper, the duplicate being kept by the person issuing the order so that he may check his bill covering supplies furnished his department during the month. The order when received by the storekeeper is registered, by means of a duplicate numbering machine, on the order and also on a record sheet. This is done to avoid loss of an order and to show the proper deduction for supplies issued.

The storekeeper places the stock card number on the order and passes it to the office. With this information, the pricing clerk readily locates the stock card and notes the unit price for each item. Extensions are then made and rechecked and the order is ready for the billing.

In addition to direct delivery, supplies are furnished in carload lots to company plants situated on the line of the company's railroad at distances of 4 to 10 miles. During a normal year this amounts to 360 carloads. These supplies are delivered on a special requisition which orders (*Continued on page* 557)

4711-2

CALUMET & HECLA CONSOLIDATED COPPER CO.
STOCK RECORD

NAME OF ARTICLE PIPE — 6" GALVANIZED STEEL — LOCATION NO 2 WHSE — SECTION 3 — MINIMUM

UNIT COST	1 00 AVER	96 FT	95½ FT	97 FT	96 FT	1 02 FT
DATE	34199	40367	46472	48115	50877	52600

OLD BALANCE	REFERENCE	DATE	DESCRIPTION	PRICE	CHARGES	V	CREDITS	BALANCE	RECEIVED FROM OR SOLD TO	OLD BALANCE	RECEIVED	DELIVERED	BALANCE	ACCOUNT NO
243 99	BR	3/5	240 FT 6" GALV PIPE	1 00	240 00			483 99	85	1308 17		240	1148 17	
384 39	BR	5/8	232 FT 6" GALV PIPE	1 00	232 00			616 39	140	1148 17		232	916 17	
	38094	5/17	1500 FT 6" LAP WELD STD WEIGHT GALV WROUGHT STEEL PIPE						I E SWIFT & CO					
185 32	528	5/13	100 FT 6" GALV PIPE	1 00	100 00			285 32	J08 C 197	916 17		100	816 17	
88 22	JFB	6/6	23½ FT 6" GALV PIPE	1 00	23 50			111 72	158	816 17		23 50	792 67	
133 56	WIC	6/11	640 FT 6" GALV PIPE	1 00	640 00			773 56	158	792 67		640	152 67	
	38094	7/5	1569 FT 11"						I E SWIFT & CO	152 67	1570		1722 67	
92 06	JFB	7/2	48 FT 6" GALV PIPE	1 00	48 00			140 06	158	1722 67		48	1674 67	
295 18	BR	8/9	22 FT 6" GALV PIPE	1 00	22 00			317 18	140	1674 67		22	1652 67	
	40367	8/17	500 FT 6" LAP WELD STD WEIGHT GALV WROUGHT STEEL PIPE						I E SWIFT & CO					
38 75	BR	8/31	61 FT 6" GALV PIPE	1 00	61 00			99 75	140	1652 67		61	1591 67	
	40367	9/11	504 FT 11"						I E SWIFT & CO	1591 67	505		2096 67	
204 54	5231	9/25	21 FT 6" GALV PIPE	1 00	21 00			225 54	J08 C 422	2096 67		21	2075 67	
52 73	6996	10/7	43 FT 6" GALV PIPE	1 00	43 00			95 73	475	2075 67		43	2032 67	
294 61	JFB	10/28	20½ FT 6" GALV PIPE	96	19 68			314 29	147	2032 67		20 50	2012 17	
5 76	7066	11/1	63 FT 6" GALV PIPE	96	60 48			66 24	475	2012 17		63	1949 17	
647 93	JFB	11/23	42½ FT 6" GALV PIPE	96	40 80			688 73	J08 C 469	1949 17		42 50	1906 67	
304 56	JFB	11/26	21½ FT 6" GALV PIPE	96	20 64			325 20	148	1906 67		21 50	1885 17	
368 70	JFB	11/28	43¼ FT 6" GALV PIPE	96	41 76			410 46	C 395	1885 17		21 50	1920 17	
541 34	JFB	12/5	21½ FT 6" GALV PIPE	96	20 64			561 98	146	1841 67		120	1699 17	
46 44	JFB	11/20	128 FT 6" GALV PIPE	96	122 88			169 32	J08 C 469	1820 17				
104 12	1385	12/19	41½ FT 6" GALV PIPE	96	40 08			144 20	J08 C 362	1692 17		41 75	1650 42	

INVENTORY — Date JAN 1 1930 — Unit Price .94 — 1551.39

1 96	BR	1/3	125 FT 6" GALV PIPE	96	120 00			121 96	140	1550 42		125	1425 42	
410 19	BR	1/26	254 FT 6" GALV PIPE	96	243 84			654 03	140	1425 42		254	1171 42	
44 76	BR	2/7	122 FT 6" GALV PIPE	96	117 12			161 88	140	1271 42		122	1149 42	
233 81	PH	2/20	82 FT 6" GALV PIPE	96	78 72			312 53	147	1149 42		82	1067 42	
121 36	BR	3/10	128 FT 6" GALV PIPE	96	122 88			244 24	140	1067 42		128	939 42	
	46472	4/-	600 FT 6" LAP WELD STD WEIGHT GALV WROUGHT STEEL PIPE						THE W BINGHAM CO					
00	BR	4/30	220 FT 6" GALV PIPE	96	211 20			211 20	140	939 42		220	719 42	
316 50	BR	5/7	106 FT 6" GALV PIPE	96	101 76			418 26	140	719 42		106	613 42	
	46472	5/7	586-4/3 FT						THE W BINGHAM CO	613 42	586 33		1199 75	
	48116	6/12	500 FT 5" LAP WELD STD WEIGHT GALV WROUGHT STEEL PIPE						THE W BINGHAM CO					
	48116	7/15	515 FT						THE W BINGHAM CO	1199 75	515		1714 75	
477 49	BR	7/17	134 FT 6" GALV PIPE	95½	127 97			625 46	140	1714 75		134	1580 75	
2 64	JFB	8/12	20½ FT 6" GALV PIPE	97	19 69			22 53	149	1580 75		20 50	1560 25	
364 17	36	8/19	80½ FT 6" GALV PIPE	97	78 09			442 26	STONE & WEBSTER	1560 25		90 50	1469 75	
	50877	10/3	200 FT 6" LAP WELD STD WEIGHT GALV WROUGHT STEEL PIPE						I E SWIFT & CO					
169 94	BR	10/21	266 FT 6" GALV PIPE	97	252 20			422 14	140	1469 75		250	1219 75	
	50877	11/10	267 FT 5"						I E SWIFT & CO	1219 75	267 25		1487	

Figure 1. Stock card

The Medical Department

of the Calumet and Hecla Consolidated Copper Company

By P. D. Bourland, M. D.*

AS AT present constituted, this department comprises the Calumet and Hecla Hospital, located at Calumet; the Lake Superior General Hospital, at Lake Linden; and five dispensaries, situated at strategic points; namely, Calumet, Ahmeek, and Kearsarge, the centers of mining operations, and Lake Linden and Tamarack Mill, the mining and smelting headquarters. At Calumet the dispensary is in the main hospital. At Kearsarge, Ahmeek, and Tamarack Mill suitable buildings are devoted entirely to dispensary service, while at Lake Linden the entire first floor of the company's office building is given over to medical purposes. The Lake Superior General Hospital is not owned by the Calumet and Hecla, but inasmuch as it is operated by closely affiliated interests, receives a liberal annual subsidy from the Calumet and Hecla and serves a clientele 65 percent of which are employed by the company, it is classed as one of the company's medical units. The personnel of the department consists of 12 graduate physicians, 7 registered nurses, 4 pharmacists, 3 male nurses, 2 untrained women nurses, 2 clerks, a telephone operator, and 8 others doing cleaning and kitchen work, bringing the total to 39. The employes of the Lake Superior General Hospital are not included in this summary, but for accuracy in the description of the company's welfare service it should be stated that they average 9 or 10.

The larger part of the force enumerated is concentrated at Calumet. Seven of the 12 physicians are located here, with 3 at Lake Linden and Tamarack Mill, which are contiguous, and 2 at Ahmeek. The doctors at Calumet have offices in the Calumet and Hecla Hospital, and the others in the several dispensaries, with the exception of Kearsarge, which is serviced by one of the Calumet doctors. The administrative and clerical offices of the department are also at the hospital in Calumet.

Inasmuch as the growth of the medical department of the Calumet and Hecla reflects not only the growth and productiveness of the property but also the evolution of the idea of health service to employes of large industrial concerns, it may be worth while to trace the history of this department from its small beginning in 1867 to its present considerable proportions.

In 1865 and 1866 mines were opened on the Calumet and the Hecla locations as separate concerns, and Dr. Brunschweiler, who had been at the Cliff mine and prior to that at one of the Ontonagon County mines, was stationed at the properties by the arrangement of the two companies. He was given office room in one of the mine buildings. Erection of residences for the superintendents of the two properties was begun early in 1867, but before its completion the companies were merged and one of the houses was finished as a medical dispensary and hospital. While the Calumet and Hecla can not lay claim to originality in engaging a mine physician, this setting apart of a building solely for dispensary and hospital purposes is believed to represent the first action of the kind on the part of an American industrial corporation. This was in 1867, and the medical department has functioned continuously ever since.

Additions have been made from time to time to the hospital building which, together with such interior rearrangements as medical and surgical progress have demanded, have kept the plant efficient. The last general reconstruction and new furnishing and outfitting was done in 1924.

The building has two main floors, with a basement and an attic. In the basement are located pharmacy preparation and storage rooms and the morgue, also the kitchen, pantries, electric refrigerator and nurses' dining room. Access to upper floors is by means of front and rear stairways and an electric elevator large enough for bed transport. On the main floor at the entrance is the spacious waiting room, one end of which is partitioned off as the pharmacy, where medicines of highest quality are dispensed by registered pharmacists on formal prescription by the physicians. Here also is the telephone exchange, the operator of which attends to the reception of patients and their direction to the offices of the several physicians. Each consulting room is equipped with a telephone, and such requests for home visits as can not, for various reasons, be transmitted directly to the doctor called are received by the operator and recorded on a special form with reference to the nature of the case, urgency, and other data.

On either side of the long hall which bisects this floor from the waiting room to the rear of the building lie the doctors' consulting rooms, the administrative office, a treatment room, a dark room, and in the wings are the laboratory, library, minor surgery and dressing department, X-ray laboratory, and record office. The treatment room is equipped for genito-urinary and gynecologic treatments and also for ultraviolet therapy, the source of which is an air-cooled mercury vapor lamp. The dark room is fitted for eye, ear, nose, throat, and sinus examinations. The laboratory is arranged for routine chemical, microscopic, and bacteriologic work, having in its equipment excellent microscopes and an electric incubator and a large amount of such work is done by the physicians. Kahn precipitation tests, which are done on every in-patient, are sent to the State Laboratory at Houghton, 10 miles away, and tissue diagnosis is done by the Department of Pathology at the University of Michigan. The laboratory is also equipped with a Roth-Benedict metabolimeter. Tests with this instrument average a hundred per year.

The library serves as reading, meeting, and recreation room. In addition to a general medical library of about 900 volumes, all important medical periodicals are on file. Regular library methods are followed in arrangement and cataloguing. The room is attractively furnished and lighted and its atmosphere is such as to encourage

* Chief of the Medical Department.

study. A monthly meeting of the staff is held in this room, at which the work of the organization is reviewed and discussed. These meetings are very valuable and attendance by every member is mandatory.

All accident cases are received in the minor surgery and allocated according to the necessities of treatment. Ambulatory cases report here for care as directed by the surgeons in charge. Two surgeons devote their entire time to this work, which is closely checked and guarded by carefully kept records, which are of more than usual significance in that the company operates under the stringent Michigan compensation law. A trained orderly assists the surgeons. Dressings in this department run from 16,000 to 18,000 a year.

The X-ray department is equipped with efficient apparatus for all Roentgen work with the exception of deep therapy. For use in wards and private rooms there is a mobile unit of latest type, which has proved very satisfactory. About 900 X-ray examinations are made annually, a large number of these being in the way of medical, genito-urinary, and dental diagnosis. The physician in charge of this work is a member of the American Roentgen Ray Society.

The second floor is devoted to the medical and surgical care of in-patients. There are 24 beds, with the possibility of an increase to 27. Of the four private rooms, two may be used as two-bed wards. An eight-bed ward and a four-bed ward for men and a six-bed ward for women, each of which will accommodate an extra bed or two if urgent need arises, bring the total to the figure named. In connection with these wards and rooms there are adequate bathrooms and lavoratories. The rest of this floor is taken up by the main operating room and a smaller operating room for contaminated cases and tonsil work, the sterilizing room, preparation and storeroom, utility room, and conveniently located electric refrigerator.

Efficient and up-to-date equipment for all branches of general surgery characterizes the operating rooms. For anaesthesia, ether, nitrous oxide and oxygen, spinal or local, is used according to choice or necessity. As to both general and urgent surgery, it is believed that in equipment and results obtained the Calumet and Hecla Hospital need not fear comparison with much larger institutions.

The average number of patients hospitalized annually is 700. This large turnover in a 25-bed hospital is accounted for by a relatively large number of tonsil cases, most of whom stay but one day; such cases number about 200 a year.

The medical department of the Calumet and Hecla Consolidated Copper Company gives full medical and surgical service to employes, their wives and minor children. Obstetrics is included. For this professional work there is no charge other than the small monthly deduction, which is the same for both married and single men. At the hospital, room and board is charged at the rate of $2 per day or $13 per week for the wards, while semiprivate and private-room accommodations may be had for $2.50 to $5 per day. Operating room charges vary from $3 to $10, according to the amount of work and material involved. There is no fee for anaesthesia, X-ray examinations, laboratory procedures, or special diagnostic technique.

All cases admissible to a general hospital are received at the Calumet and Hecla Hospital except obstetrical cases, which are cared for at the Memorial Hospital, a well-equipped public institution within easy reach and at which the charges are very reasonable. At the Lake Superior General Hospital at Lake Linden obstetrical cases are also received. The Calumet and Hecla Company has contributed generously to the Memorial Hospital in recognition of its value to the company employes and the community in general.

The high grade of care given hospital patients is deserving of mention. Daily baths and changes of bed linen are routine, and all service to patients except that of the most trivial nature is given by graduate nurses. A silent call system operates from each bed. Food is of the highest quality obtainable, is well prepared and served in an attractive manner. The employes in general have a friendly feeling for the medical department and hospital and apparently feel that the institution is peculiarly their own.

Regular office hours are held from 8 to 10 o'clock in the morning and from 4 to 6 in the afternoon. Operative work is so arranged as to interfere as little as possible with the observance of these hours, which the physicians feel that only urgent necessity can absolve them from attending. On Sundays and holidays a single office hour is held, from 12 to 1, and the physicians alternate in pairs in conducting this. The pharmacy is open from 8 in the morning to 7 in the evening every day in the year, and a pharmacist is on call at all hours. Medicines are dispensed without charge, but only on prescription. Drugs and pharmaceuticals of the best quality only are used, many of the stock formulas being prepared in the hospital pharmacy.

While no member of the medical staff is in a position to limit his practice to any specialty, each physician has one or more favorite lines of work in which he is better than average. The surgery of all types of injuries, with especial interest and opportunity in the management of fractures and of infections of traumatic origin, general surgery, gynecologic surgery, obstetrics, transfusions, general medicine in its application to both acute and chronic conditions, pediatrics and some of the lesser subsidiaries of these great divisions, are represented among the special interests of the 12 men forming the group. For ophthalmic work an outside consultant is used, as there is not enough of this work to warrant the permanent employment of a specialist. Many of the more technical diagnostic methods are available, including complete X-ray study of the gastro-intestinal tract, cystoscopy and ureteral catheterization, and the determination of the basal metabolism. No laboratory technician is employed, but the doctors are all competent to do routine laboratory work, and highly specialized work of this nature is sent outside, as before stated. It will be seen that in an organization of 12 men a fairly efficient group can be assembled and maintained, and this has been and is being done in the Calumet and Hecla Medical Department.

The Michigan "copper country" is an old established mining district, and there is, of course, a considerable population engaged in the many mercantile and professional affairs incidental to community life. This affords an opportunity for private practice to the Calumet and Hecla physicians, and such work is accepted by them with the full sanction of the company, the understanding being that under no circumstances are the interests of the employes to be neglected. It is believed that this provision is faithfully observed. In no case does a company doctor maintain an office outside of the company hospital or one of the dispensaries, and in no way is discrimination made between private and company patients to the detriment of the latter. When, on the same basis, it is possible to accommodate them, private patients are received as in-patients at the company hospital.

The extent to which this medical service is used by the several communities which it serves is best illustrated by the figures covering the average annual attendance at the dispensaries, the number of patients hospitalized, and the number of visits made by the doctors at patients' homes. Attendance at all dispensaries averages 84,000 per year. Home visits by physicians average 30,500. The average annual number of in-patients at the Calumet and Hecla Hospital is 700, and at the Lake Superior General Hospital 320. Between five and six hundred obstetrical cases are attended annually in the hospitals and homes by members of the staff.

Operative cases at the Calumet and Hecla Hospital for the last six years totaled 3,592. Of these, approximately 1,000 were so-called major operations. Among these major items are recorded 368 appendectomies, 109 hernia operations, 153 thyroidectomies, and others in lesser numbers and of a very general range, including many of accidental origin. Of interest among the minor cases are 1,525 tonsil operations. At the Lake Superior General Hospital during the same period there were 340 major and 1,008 minor cases. Tonsil operations to the number of 743 are recorded here.

It will be seen that tonsil removal holds a high place in the system of preventive medicine practiced by the department, and in support of this position may be cited the practical elimination from the communities served of rheumatic fever and St. Vitus' dance with their invariable heart inflammations and the marked reduction in all diseases of childhood involving the throat, ears, and respiratory mechanism. In the case of diphtheria, toxin-antitoxin has also played a large part in prevention.

While these figures representing hospital activity are of great significance, sight should not be lost of the really immense amount of work done by the physicians in the homes. This constitutes by far the larger part of the department's work, and it is as varied as are the ills to which flesh is heir. No statistical comment is offered beyond reference to the 30,500 home visits to which allusion has already been made.

Since its beginning the Calumet and Hecla Hospital has been the center of the township health service, and the health officer has been a member of the hospital staff. Among the more important duties of this service is the chlorination and weekly bacteriologic testing

of the public water supply and the furnishing of fresh diphtheria and scarlet-fever antitoxin for use when needed. Vaccination against smallpox and toxin-antitoxin administration are to be had at any time on application.

The Calumet and Hecla Hospital is served by a modern motor ambulance and two horse-drawn ambulances, for use when snow makes the use of the motor impossible. All main roads in the district are kept open throughout the winter and easy communication is the rule between the most distant mine locations and the hospital.

Some time ago it was found that it would be necessary to provide a home for the nurses entirely apart from the hospital, to maintain efficiency in the nursing staff. With this in mind, a large dwelling belonging to the company and located near the hospital was remodeled and appropriately furnished, and two years ago the nurses moved in. Here each nurse has her own room, and there are pleasant sitting rooms and the other appurtenances of a home. The building is in the care of a housekeeper, who also does the washing and ironing, which in an establishment of this kind is a large item. From the viewpoint of results, this home has fully come up to expectations.

In the rehabilitation of injury cases massage and manipulation have always been included. At one period in the history of the department this work was done at the hospital, but for some years it has been necessary to use outside help, on account of lack of room. Last year in connection with a systematic study of disability periods in different types of injury cases, with a view to possible and legitimate reduction in compensation costs, it was determined to widen the scope of this work and to include gymnastic therapeutics and properly applied heat and light therapy. A large room in the basement of the company's bathhouse has been furnished with apparatus sufficient for a modest beginning, and has been placed in charge of a trained masseur, who works under the supervision of the compensation surgeons. As a means of building up and maintaining the morale of the patient undergoing a tedious convalescence from a disabling injury, apart from the actual therapeutic value of the measures used, it is felt that this new department promises much. Apparatus installed includes dumb-bells, medicine balls, pulley weights, a rowing machine, a stationary bicycle, and two Zander machines. There are also shower baths, foot baths for alternate hot and cold immersions, and a powerful infra-red lamp. The masseur has had the best of sanitarium training in his work and in hydrotherapy. For the six months this department has been in operation, treatments have averaged 400 per month.

The Employes' Aid Fund

The establishment of the Calumet and Hecla Employes' Aid Fund dates back to 1872. Full membership on the part of the personnel is traditional, the only nonparticipants being a few who have been disqualified by adverse medical report at the time of employment and those who have had the full measure of help allowed by the by-laws. Membership is, however, not compulsory.

The fund represents a cooperative effort on the part of company and employes to provide for those who are unable to work on account of sickness, and also for those cases of injury met with under conditions not covered by the State Compensation Act; in other words, injuries suffered outside of working hours. The Compensation Act, effective in 1912, automatically set apart the group of injuries received while at work which had up to this time been participants in the benefits of the fund.

At first, the company and the employes contributed equally to the fund, the total monthly collection from the latter being matched by the former. Then came periods during which no collections were necessary, as the supply of funds exceeded the outgo. The company, however, continued its payments during these prosperous times and maintained them until the fund became self-sustaining. Total contributions by the company were $625,000. The contribution by the individual employe has never been over 75 cents per month, and for the greater part of the life of the fund not over 50 cents. At one time it was only 35 cents.

Originally the indemnity to a member of the fund entitled to aid was $25 per month or a dollar a day, but as living costs mounted, this was increased to $1.50 per day or $37.50 per month, which is the rate now prevailing. The present individual monthly contribution is 75 cents. The by-laws of the fund authorize payment for a period of eight months and also provide that a member who has received benefits for this maximal period shall pay no further assessments for its support and receive no further indemnity from it. As a matter of fact, the administrators of the fund are very lenient in this respect, and many a deserving case has been carried for double the specified period, and even longer. Payment begins on the sixth day of disability, but if more than 20 days are lost the first 5 days are included.

The affairs of the aid fund are managed by a committee, of which three members are elected by the employes and two are appointed by the company. The employes elect their representatives annually, while the company appointees serve indefinitely. Provision is made that a member of the medical staff shall always sit on the committee.

The physical examination which all employes must undergo helps to protect the fund from impositions of gross character, but once accepted for employment, the integrity of the individual becomes the main defense against abuse, as only under exceptional circumstances does the attending physician question the honesty of the employe and the legitimacy of his claim for indemnity. Doubtful cases are brought before the aid fund committee, the fair and friendly attitude of which is recognized, and decisions by this board are final. So broad is the spirit of the institution that certificates of disability from other than company physicians are accepted at face value should employes wish "outside" medical attendance.

Should a member of the aid fund die, the sum of $250 is paid to his dependents by the company. This payment does not come from the fund and has no connection with it, nor with the group insurance plan which is described in another section.

Up to January, 1931, total payments to employes from the aid fund amounted to $2,350,000, and there was in the fund on that date, in cash and securities, a balance of $150,000.

SUPPLY DEPARTMENT

(*From page 554*)

are made in triplicate conforming to the regular charge order; the extra copies being used as bills of lading accompanying the shipment for checking purposes by the department receiving the supplies.

Where materials are stored at different points, and for bulky material such as lumber and timber for the mine, there is a man in charge whose duty it is to see that proper orders are furnished for withdrawals and that receipts are checked and credited.

The billing and accounting operation is done with three Elliott Fisher accounting machines. The bill is made in two or more copies as required together with the ledger sheet, the stock card record and a proof sheet all in one operation. Sales to subsidiary companies or others are sent to the accounting department for collection, and copies of the operating accounts are sent to the department heads for their information.

From the ledger sheets, a statement known as "Supplies Used" consisting of over 700 accounts and work orders is sent to the accounting department monthly for their use in making up the cost sheet.

In addition to purchases from others, considerable stock is manufactured in the company's own shops, such as brass and iron castings, machine parts and mill work, tools, babbitt, etc., the necessary raw material being carried in stock for this purpose. In ordering this material a work order is issued to which is charged all supplies and labor necessary in the manufacture of the item; the price of this material and the receipt is posted to the stock card in the same manner as material purchased on invoices.

The supply department is also the clearing house for the brass and cast iron foundry, which during 1930 turned out 92,399 lbs. of brass and 3,015,128 lbs. of iron.

All railroad charges for switching, crane service and transportation of coal to the several departments (amounting to 15,000 carloads in 1930) is cleared through the same department.

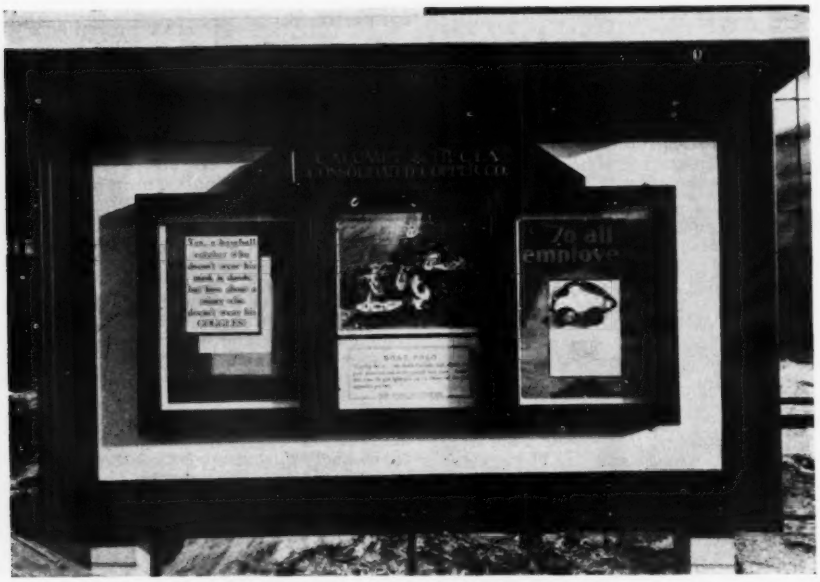
A traffic department is also maintained which passes upon all routing of supplies, in and out; also all freight rates are checked here and vouchers drawn on the accounting department for payment.

During the year 1930, 1,659 carloads of material were unloaded, of which 50 percent was lumber and timber amounting to 12,000,000 feet, besides the vast amount of LCL material received by rail and rail and lake.

Supplies are separated into five classifications: coal, explosives, iron and steel, lumber and timber, and general, which as of December 31, 1930, had a value of $2,612,750.95. The practice of purchasing coal and other heavy material during the lake freight season necessarily leaves a near-peak inventory at the end of the year, but the saving by this method far outweighs the disadvantages.

This simple but practical system, combining information to and cooperation with department heads concerning stock on hand, perpetual inventory record, stock record control, distribution and accounting, makes it possible to keep the stock complete and yet within reasonable bounds, which is the primary object of a supply department.

SAFETY and



Four of the three-panel boards shown at the top are located in public places

Twenty-six like those in the center above are hung where the greatest number of employes will see them

Two bulletin boards like that at the bottom are hung in schools

IN 1866 the Calumet mine and the Hecla mine were started side by side at Calumet. Not many miles away a number of other mines had been operating for 15 years or more, and there had grown up in the district a style of organization typical of the rough nature of the pioneer. The usual custom at that time for starting such an industry was to form a combination of absentee officials looking after the financial end of the business with a more or less "hard-boiled" construction and operating head who remained at the mine. The term "hard boiled" is intended to describe a man schooled in the handling of extra-hazardous projects and trained to think of nothing but the speedy advancement of the work entrusted to him. To put the safety of his workmen and of himself ahead of, or even abreast of, the job in hand would be an unthinkable form of cowardice in one whose familiarity with many hazards had resulted in contempt for them.

That it was intended to start the Calumet and Hecla mines on this basis seems certain; but when the work had progressed less than a year, Mr. Alexander Agassiz came to Calumet to take over the local management. There is ample evidence that he undertook the personal supervision of the work with an open-minded appreciation of the many risks and dangers of the enterprise and that he gave more consideration than was usual in the district to the safety of himself and the rank and file of employes associated with him. From that day to this "the man in direct charge of the work" has been held to strict account for the safety of the men under him, and in carrying that responsibility he has had the benefit of continuous personal contact with the highest official in the operating organization. Every man on the job has learned that the sure way to draw approval and praise for his work is to conduct it in a manner that safeguards life and limb to the fullest extent possible, and that to sacrifice these safeguards to speed is certain to draw censure on himself.

Thus from the start the safety and accident-prevention policies of this company have been placed upon the department heads, who, in turn, have had the

* Claim and Employment Agent.

ACCIDENT PREVENTION POLICIES

By O. F. Bailey*

whole-hearted support of the management with sympathetic understanding of the many problems involved. During the past 20 years safety inspectors, safety committees, claim and employment departments, safety engineers, etc., have been added to assist the department heads in carrying their increasing responsibilities. The safety movement with "Safety First" as its slogan did not really get under way until after the Central Claim Department was organized in 1911. The same department naturally took on the necessary additional work when the Michigan Workmen's Compensation Law became effective, late in 1912. Formerly each of the several subsidiary companies, now embraced in the Consolidated Company, looked after employment matters and kept employment records independently. But during 1914 a Central Employment Department was created within the Central Claim Department, thereby coordinating all the "Safety First," claim, and employment activities under one directing head.

Hiring Men Dovetailed with Safety Policy

The department heads and their assistants, being held responsible for the safety of workmen, have the right to hire and to discipline to the extent of dismissal. There is benefit, however, in doing both under the supervision of the central office. Hence a department officer uses the form shown in *Figure 1* when he desires to hire an applicant.

A specimen case where former service is claimed has been selected because it best illustrates the benefits from central office supervision. However, if John Smith tried to cover up his previous record even to the extent of changing his name, his chances of escaping detection would be less than 1 in 100. Therefore, when he presents the Request for Employment he is confronted with his previous record on a loose-leaf ledger sheet 8½ by 14 in. produced from the nonworking files in the central office. One side of this record is devoted to John Smith's personal and family history, date of birth, nationality, and previous employment outside of his service with this company; facts given by him at the time of his first employment and brought up to date each time he reentered the service. On the other side is shown the pay roll number assigned to him (this number is never taken from him, whether his record is in the working or nonworking file, unless it is known that he is deceased), also his enrollment card number, which is permanent, and records of physical examinations and all papers pertaining to the act of his employment (excepting the loose-leaf record) are filed. At the time of his first accidental personal injury an accident file number was assigned to him; under it is filed all reports pertaining to each and every such injury received by him while in the company's employ. This side of the record also contains an entry for each period of service under each class of employment and in each department where he may have been employed, as shown in *Figure 2*, for example.

Also, in other spaces on this side of the sheet are posted the amounts received for "sick benefits" and "workmen's compensation" by months and years. The balance of the sheet is given over to a detailed record of the reasons for discharges, lay-offs, quits, etc., dates of physical examinations and their results, and to changes in his home address.

With this complete information at hand at the time of hiring, the central office is able to assist the department heads in selecting *only safe, steady workers*, or at least to call the applicant's attention to the bad spots in his previous record. If John Smith has no previous record with the company, the central office secures from him a record of his previous employment with other companies, to be investigated as circumstances seem to warrant. If he is accepted on his record, he must submit to an examination to determine his physical fitness for the work for which he applied. If passed by the central office, the applicant is given an enrollment card reading as shown in *Figure 3*.

When there is a shortage of men and applicants come first to the central office, their previous records are looked into and, if satisfactory, they are sent for physical examinations. If passed, they are given enrollment cards and directed to the departments in need of men. If accepted by a department head, they are ready to start work without returning to the central office.

Claim Department and Safety Policy

When a lost-time, accidental, personal injury occurs, two formal reports (surgeon's and foremen's) are due in the claim department within 24 hours; fatal and serious injury cases are reported at once by telephone and regular reports follow later. The surgeon's report is usually the first to be received and comes in by messenger at 8 a. m. As soon as it has been received, a department memorandum like the specimen is made and mailed to the department head and to the chief safety engineer.

This brings two results: Immediate investigation, if warranted, and a report from the injured man's foreman, if not already made. The foreman's report usually follows the surgeon's report; but in case none has been received, the surgeon is notified of the accident and is furnished the injured employe's address so that contact can be made and necessary attention given. From accident reports so much is learned that is valuable in inaugurating safety practices that care is taken to secure at the start both the injured man's statement (as related to the surgeon) and the foreman's statement as to how the accident happened. From the information contained in the reports of the surgeon and the foreman a card record is made of each accident, as shown in *Figure 5*.

This card is then sent to the tabulator department and a special card is punched for use in the automatic tabulating and sorting machine. It is then returned to the claim department and is the basis for weekly and monthly reports and comparative statements for the benefit of department heads and safety engineers. (J. W. Alt's article explains these reports in detail.) Standard practices are followed closely in the classification of accidents by departments, nature of accident, nature and extent of injury, occupation of injured employe, his age and experience, nationality, hour of accident, etc., and nothing would be gained for the purposes of this article by treating them more fully. This company, however, goes a step further than most others do in that it keeps a continuous card record for each employe from the time of his first injury, as illustrated in *Figure 6*.

Note that this specimen record includes one home accident. Company physicians and surgeons take care of employes and their families in case of sickness or accident and are required to report all injuries cared for, including

Thirty of these single boards are distributed through workshops

REQUEST FOR EMPLOYMENT

February 15, 193 1

TO CENTRAL EMPLOYMENT OFFICER:
The Bearer John Smith
makes application for employment as
Miner at Hecla Mine
If approved by you I can place him in the position which he desires.
Remarks No previous employment this Department but claims several years service other departments.

NOTE—Give what you know of previous employment under remarks.

John Doe.
Department Officer

K. P. Co.—24985

Figure 1

CALUMET & HECLA CONSOLIDATED COPPER CO.
AND ALLIED COMPANIES
CENTRAL EMPLOYMENT OFFICE
Enrollment Card No. 7001

Good Only At Hecla Mine Not Good After

The Bearer John Smith has filed application for employment. He has passed the physical examination and is approved by this Department for employment as Miner

His Description
Height 5'10" Weight 172 Eyes Blue
Hair Light Age 41 Nat. Irish
Marks Little finger rt. hand amputated

JOHN DOW
—Employment Officer.

NOTE:—If employed secure Pay Roll Number from this office, fill in back and return this card to Employment Office.

Figure 2

JOHN — GIVEN NAME; SMITH — SUR-NAME

Enrollment Card No. 7001 Pay Roll No. 47851

EMPLOYMENT

Date Entered	Occupation	Rate	Company	Dept.	Date Left	Reason
1-16-04	Tram	3.50	C & H	R.J.S.	4-15-10	transfer
4-15-10	Miner	4.20	"	Hecla	5-20-15	Quit
7-15-20	"	4.80	Alumeek	#2	8-24-25	Dis.*
6-12-28	"	4.80	C & H	Cal.	8-12-30	L.O.

*Detail of cause shown in space provided.

Figure 3

Employe's No. Name Accident No.
Name of Company Lode Place Cause of Accident
Detail of Accident
Contributary Cause
Nature of Injury
Detail of Injury
Time Date of Injury 193 Occupation Nationality Age Experience
Estimated Time Lost Wks. Days Actual Time Lost Wks. Days Amount Paid $ Married Single
Report Received From Date
Date Discharged by Surgeon Date Returned to Work
Remarks

Figure 5

Calumet & Hecla Branch (Underground) Received 2-4-31

Surgeon's Report of Employe Injured

47851 John Smith, age 24, miner, injured about 9.30 a. m., 2-3-31, at No. 6 Hecla.
First seen by surgeon: 5 p. m., 2-3-31.
Patient's statement: Pick fell and hit his right foot.
Doctor's statement: The back of right great toe is abraded and red. There is not much swelling.
Estimated time lost: Seven to ten days.

Figure 4

Employe's No. 47851 Name JOHN SMITH

Calumet & Hecla Cons. Copper Co. RECORD OF INJURY

Accident No.	DATE	PLACE	NATURE	Dis. Surgeon	Amt. Comp.	REMARKS
3632	1-20-12	#2 Shaft	Wd. eye & cheek Bruised leg.	2-1-13		
3632 +1	5-12-15	#6 Hecla	Frac.finger	7-12-15	$66.64	
3632 +2	12-15-17	#6 Hecla	Lac. palm	1- 5-18	$ 6.67	
3632 +3	4-23-18	Tamarack	Pain in Back	On Aid		
3632 +4	1-11-20	#7 Hecla	Wd. shoulder	4- 7-20	$40.82	
3632 +5	2- 2-21	R.J.S.	Scalp wound	Lost No Time.		
3632 +6	3- 1-24	#7 Hecla	Ulcer of Eye	3-15-24	$11.10	
3632 +7	6- 3-26	Home	Dis. shoulder	On Aid		
3632 +8	3-11-29	"A" Sh.	" lt. shoulder	4- 6-29	$51.00	
3632 +9	2-13-31	" "	Lac.lt.1st finger	2-14-31		

Figure 6

Forms used in keeping enrollment and accident records

those happening outside the employe's regular work.

This system has been in effect since January 1, 1912. When posting a current accident the individual's record is noted as to frequency of injury and tendency to prolonged disability; when it appears to warrant special attention, a transcript of the record is made and sent to the department head in order that the injured employe may be talked to (if the circumstances seem unusual) before he is permitted to return to work after recovery from his latest injury.

Distribution of Monthly Compensation Pay Roll

Each department is furnished with a statement showing the amount paid during the month to employes on account of accidental personal injuries. The current month's payments, of course, include compensation on account of injuries received during previous months or years, for fatal cases run for 300 weeks and total permanent disability cases run for 500 weeks. This report is intended to keep the accumulating cost of accidents before the department head and his assistants. It is divided under the following items: Amount paid during the month—for disability cases, for fatal and specified injury cases, and total; and it shows (*Continued on page* 562)

Figure 1. The public library at Calumet

Figure 3. Part of the general reading room

Calumet and Hecla Library

By Mrs. Marie F. Grierson*

SATURDAY, September 17, 1898, was a gala day in Calumet, when the new public library was opened to the people of this town and vicinity. The attendance of over 4,000 persons convinced everyone that the library was appreciated and that it would open new fields of interest to old and young. This interest has continued and increased through the years, and the library is now considered one of the most useful and enjoyable of the fine institutions fostered by the management of the Calumet and Hecla Consolidated Copper Company.

In any mining community, the mine is the center around which everything revolves and on which everything depends. If the mine is prosperous, the town shares in its prosperity, and is depressed in its periods of depression; and at all times so very much depends on the attitude of the company toward its employes and the towns people. This library is particularly fortunate in being part of a corporation whose name is synonomous with fair dealing and generosity not only to all connected with it but to the general public as well.

It was the whole-hearted interest and far-seeing wisdom of Mr. Alexander Agassiz, who was then president of the Calumet and Hecla, that inaugurated the movement for establishing a public library in Calumet. Mr. Agassiz was vitally interested in the project and its future work and suggested a policy that made it possible to serve the people in a most satisfactory way; and this policy is still followed in carrying on the work of the library. As a result of it, the library supplies books, periodicals, and other matter to the employes of the company and to the entire population of Calumet Township. Not only this, it also grants special cards to residents of neighboring towns through Houghton and Keweenaw Counties, on which they may borrow nonfiction. In fact, the library is open to anyone who may wish to use it, and no money deposit is required at any time. This policy has brought splendid results in the work of

* Former Librarian.

Figure 4. The children's reading room

Figure 2. Book delivery room

the library and has established cordial relations between the public and the library staff.

The library cooperates with the schools, churches, clubs, and other community centers in every way, but especially by having books and periodicals and similar material to supplement the work of these institutions. It also helps many young people who are taking correspondence courses by buying and loaning to them the special books needed for their work.

The library building is unique in appearance and attracts attention. From the first glimpse of its large book-delivery room through the open door, one is impressed with the homelike atmosphere and the absence of the public building aspect of things. The same is true of all the rooms in the building. The comfortable furniture, the good pictures and statuary, the presence at all times of plants and flowers, the open shelves, the alert interest of the patrons who happen to be present, and the absolute freedom with which everybody uses every department—all of these emphasize the homelike atmosphere present throughout.

In the book-delivery room is the card catalogue, which so many people, old and young, use every day. Here are found, also, cases full of interesting mineral specimens that are of special interest to many of the local patrons as well as to out-of-town people. In another corner is a collection of over 100 Underwood and Keystone travel tours, which circulate very freely and are a delight to hundreds of people of all ages. Another section of shelves contains a collection of books and pamphlets on all kinds of needlework with beautiful patterns and designs, which are used by many of the foreign-born women as well as others, for the patterns speak a universal language. In this room there is also a case containing nearly 12,000 clippings and pamphlets that supplement the books and periodicals, especially in the reference department. From 1,500 to 3,000 subjects are looked up annually for the use of patrons.

In an adjoining room are cases containing many clippings and pamphlets on the early history of the copper country, its people, early mines, and so on; also a very good collection of 750 mounted photographs illustrate the clippings.

In another room there are more cases containing over 14,000 mounted pictures, reproductions of the world's masterpieces, pictures on history and geography, nature study, portraits, religious subjects, and many others. The library circulates from 2,500 to 6,000 of these pictures annually, and the good they do is inestimable.

There is also a fine collection of technical books, including bound volumes of technical magazines, which are very popular with men and boys and circulate very freely. Everywhere it is recognized that, other things being equal, the man whose practical knowledge of his work is improved by theoretical acquaintance through the best literature will easily outstrip the mere perfunctory worker. A good collection of over 6,000 public documents circulate and are also used in the reference department. A collection of 232 maps are very useful at times, and from 30 to 70 circulate annually. All other circulating volumes are in the main bookstacks and include those that are usually found in public libraries.

Soon after the opening of the library, it began to purchase and circulate foreign-language books among a large number of residents who came from other lands. From a small beginning, this collection now numbers over 6,000 volumes in the French, German, Italian, Swedish, Norwegian, Finnish, Polish, Slovenian, Croatian, and Hungarian languages. The books are freely used and give pleasure to many who have not yet acquired a reading knowledge of the English language. In selecting books for this collection, the Bible, dictionaries, translations of good English and American fiction, translations or original works on American history and biography are chosen; in fact, any good books describing America, its institutions, and its great men and women, books on citizenship, original works on history, travel, biography, poetry, and fiction are very popular and useful. The circulation of these foreign books has been from 2,600 to 10,900 annually.

The general reading room has on file a fine collection of 176 current magazines and newspapers, many of the more popular ones being duplicated so that current numbers may circulate, as well as the back numbers. The children's reading room is pleasantly situated near the main reading room and has 20 fine, current magazines, nearly all of which are duplicated. The extra copies and the back numbers circulate very freely among the boys and girls who are very fond of their own reading room and use it constantly. The library also maintains a reading room and book-delivery station at Lake Linden, where the stamp mills, smelting works, and power plants are situated. The annual home use of magazines from these three reading rooms has increased from 1,200 to 89,200. The number of persons using the periodicals in the reading rooms has increased from 27,500 to 47,000 per year.

The library as an educational factor in the community is particularly conspicuous in the work it does with the boys and girls. The children of Calumet are among the most enthusiastic patrons of every department. They take advantage of all it offers in a way that ought to convince the most confirmed pessimist that the youth of the land is out after knowledge and at an early age. The books, as well as the magazines, for the young people are very carefully selected and only the best are purchased and placed on the shelves. Duplicate copies of many of them are provided to meet the demand. The annual circulation of children's books has grown from 27,900 to 71,000. During the months from October to April there is a Story Hour every Saturday afternoon for the boys and girls. The weekly attendance varies from 75 to about 125.

The wonderful interest awakened among the people who attended the opening of the library so long ago has increased year by year, and the same enthusiasm is manifested by the patrons now as in the past. The library has improved and the number of books has grown from 5,000 to 52,000, and the circulation of books has increased from 55,000 the first year to 188,800 recently.

Figures can not tell of the actual benefit accruing to the community from the library, but they indicate the place it holds in the minds and hearts of the people. It furnishes instruction and inspiration, recreation and companionship to all the people of Calumet and vicinity.

SAFETY AND ACCIDENT PREVENTION

(*From page* 560)

the number of case carried under each item. It covers four periods for comparative purposes:

This month.
Same month last year.
This year, including this month.
Same months last year.

Departments are subdivided; for instance, the Conglomerate Lode is one major underground department under a head mining captain. It is composed of four branches, as follows: Calumet mine, Hecla mine, Red Jacket shaft, and "A" shaft. In turn, the Calumet mine comprises No. 2 shaft, No. 4 shaft, and No. 6 shaft; likewise the Helca mine and Red Jacket shaft branches each consist of several shafts. The report furnished to the head mining captain of the Conglomerate Lode shows the information referred to above for each shaft separately with a summary for each of the four branches and a final summary for the Conglomerate Lode as a whole. In the same manner, the head of each major department, both underground and surface, receives the information for his department and is furnished with sufficient copies to place one in the hands of each assistant and subforeman.

Bulletin Board Services

The bulletins of the National Safety Council are supplemented by a daily news and bulletin service under which 30 attractive boards of the three-panel type are in use and 30 single-panel boards, 14 by 17 in. All panels are protected by glass, and the inner panels to which the bulletins are attached are removable and interchangeable. One man devotes his entire time to servicing these boards.

Four of the three-panel boards are located in public places, where they may be observed by employes on their way to or from work, as well as by the general public. Twenty-six are located in change houses and other selected spots, where the greatest number of employes pass or congregate. All boards are placed in good light and are illuminated at night by indirect flood lighting. The center panel in this type of board is used for news photos, and no board is permitted to carry the same display on two successive working days. The right-hand panel is devoted to safety bulletins and is changed every second working day. The left-hand panel carries minute messages or local interest bulletins, and is changed on days when the right-hand panel is repeating, so each board receives two changes each working day.

The thirty single boards are distributed through workshops and are used for safety bulletins and minute messages especially selected for various departments, and are changed at least once each week. Public-school superintendents in two instances have provided space for posting bulletins in one high school and one grade school, which are serviced each Saturday with news photos, minute messages, and safety bulletins especially selected.

Eleven active memberships in the National Safety Council have been carried by the Central Claim and Employment Department since 1916; they are assigned to the heads of major departments.

A dwelling and garden on Calumet and Hecla location, Calumet, Mich.

By John G. Bennetts*

INDUSTRIAL and COMMUNITY RELATIONS

IN COMMON with most mining developments, the Lake Superior copper district at the beginning of operations was isolated from the rest of the world. Transportation and communication were possible only by boat during a short navigation season, and with the coming of winter, the entire community had to rely upon itself for all its requirements.

Because of this isolated location, it was natural that a mutual feeling of dependence and responsibility should exist between the employer and the employes. Being responsible for the presence of the employes, the company officials felt it their duty to see that every possible provision was made to insure their comfort and welfare. It was necessary to anticipate all needs of the community during the season of navigation to the end that everything in the nature of food supplies, wearing apparel, medical care and drugs, should be provided. In like manner, the employes realized that the company depended upon them to make the undertaking a success and lent their best efforts to promote its prosperity and stability.

Adventurous miners, largely from Cornwall, England, came into the district shortly after the discovery of mineral values on the southern shores of Lake Superior. In the year 1866, when operations at the Calumet and Hecla properties began, a number of these men were recruited from neighboring properties and formed the nucleus of the present community. To a large extent, the pioneers were unmarried men or men who had left wives and families in the homeland while they established themselves in the new industry here.

Housing

Substantial boarding houses were erected for the use of the men until they were in a position to send for their families when dwelling houses were built for them. As conditions required, additional dwellings were constructed to accommodate the growing number of employes, and at the present time the company owns over 1,500 dwelling houses. These homes were substantially built on generous sized lots, allowing space for gardens and playgrounds for children, and were adapted to the severe climatic conditions prevalent in this district. The rental charge is lower than the cost would warrant, the general rule being approximately $1 per room per month, including water. All houses have been kept up to modern requirements, and the low charge for rent has not been sufficient to cover the annual outlay for repairs and upkeep but has proved to be of great value in enlisting and retaining the good will and confidence of the employes. The company has also encouraged the building of homes by its employes and has leased lots for this purpose at the nominal rental of $5 per year. Over 1,000 employes have taken advantage of this opportunity, while others have purchased lots in the adjacent villages and have erected homes for themselves and their families.

Concrete walks have been laid throughout the principal streets of the mine location. These streets are well lighted and fences have been replaced by flowers and shrubs with the result that residents have taken increasing pride in maintaining and beautifying the lawns and grounds around their homes.

Schools and Churches

Realizing the importance of education to the residents of the district, the company erected and equipped a modern brick high school building as well as a number of grade schools for the use of the community. The high school has a present enrollment of 1,100 students and, in addition to the customary high school courses, affords opportunity for a two-year junior college course and facilities for practical instruction in manual training and general domestic science. A similar school cares for the educational needs of the people at Lake Linden where the concentrating plants are located. Because of the company's liberal policy in relation to local taxes, the schools are maintained on a high plane and compare favorably with those of any section of the state.

As operations developed in the mining industry, laborers were obtained by immigration from the more densely settled parts of Europe, and in a very short time this community was composed of a cosmopolitan population of divergent languages and beliefs. To accommodate the religious needs of the several nationalities, sites were donated and generous amounts given towards building funds for 25 churches of various creeds. As a result of this attitude towards liberal education and religious beliefs, the community has always been progressive, law-abiding and morally sound.

Health and Recreation

Recognizing the importance of a healthy and contented community, every effort has been made to provide good sanitary conditions and also to encourage all forms of recreation. The hospital and medical services maintained by the company compare favorably with those of much larger communities. The purest of drinking water is supplied to all sections of the district (including incorporated villages) by means of two modern pumping plants on the shore of Lake Superior. Drawn from such a source, this water is particularly well adapted for human consumption; but as an added precaution, it is subjected to a chlorine treatment without interfering with its palatability. In connection with the adjoining residential sections, a modern sanitary sewage system has been in-

* Chief Clerk and Assistant Treasurer.

Bronze statue of Alexander Agassiz in the Calumet and Hecla Park, Calumet, Michigan

stalled which amply takes care of all community needs. Garbage is removed from the mining locations at frequent regular intervals at company expense. A modern, well equipped bath house has been built by the company for the use of the public.

All means of healthful recreation are promoted by providing suitable grounds and financial aid, as this need develops. Experience has proved that it is preferable to encourage the members of the community to own and control those recreational facilities which they desire, with such assistance from the company as may be necessary, rather than to own and operate these facilities itself. With this view the company has erected, furnished and subsidized a modern social club open to membership of the entire community on payment of nominal dues; it has also erected and equipped a community building known as the Colosseum adapted for ice hockey and other winter sports and turned it over to a local organization for a sum considerably below its cost. It has an up-to-date armory building for the use of the local military organization, the local corps of the R. O. T. C. and community gatherings. It has assisted the golf club with a material cash donation making this popular game available to all at a moderate charge. Hockey and baseball, as well as other forms of recreation, have been fostered. Tennis courts have been provided at the mine and the mill locations and a recreational camp on the shore of Lake Superior. All of the large acreage of land owned by the company has always been open for fishing, hunting and camping. The residents of the district take much pride and pleasure in the Calumet and Hecla Park, which has been provided and kept in condition by the company. Being adjacent to the residential sections of Calumet and Laurium, it has proved very popular. All recreational facilities are available to the community at large and are not restricted to employes.

As automobiles have come into common use, the company has advocated the building of good country roads so that all may enjoy the scenic beauties of the section.

Insurance

On October 1, 1919, the company instituted group insurance for all employes. After an employment period of six months, each employe automatically becomes insured for $1,000, which amount is increased $100 per year until a maximum of $1,500 is reached. All costs of this insurance are borne by the company. After obtaining an affirmative vote of the employes, an additional $1,000 policy was issued to each employe on March 1, 1930. Premiums on this additional insurance are borne jointly by the insured and the company, the latter carrying something over 50 percent of the cost and the balance being collected quarterly from the employe. This insurance plan is much appreciated and has done much to engender a friendly attitude on the part of the employes. It has also a direct bearing on continuity of employment, as a decided drop in labor turnover has resulted from its adoption.

Pensions

In 1904, a pension system applicable to old employes was adopted. In order to meet its requirements, an employe must have attained the age of 60 years and have a service record of at least 20 years. When these conditions are complied with, the foreman or head of the department in which the employe is engaged may recommend him to the management for a pension, provided he is unable by reason of age, illness or other causes to perform his work satisfactorily. The original plan provided for a monthly pension payment for five years that amounted to 1 percent for each year of employment, based on average monthly wages for the previous 10 years. At the present time the monthly payment to each pensioner is an approximate average of the above if figured individually.

General

As mining is practically the sole industry in this district, the workmen have not been confronted with opportunities for frequent change of employment as is common in most industrial centers. As a natural result of this condition, the record of continuity of employment has been exceptionally good. It is not uncommon for two generations to be working for the company at the same time. In a few cases, three generations have had contemporaneous employment. Working records of 40 and even 50 years and more are not unusual in the organization. At the present time there are 475 men in the active service of the company who collectively have 645 children on its rolls. In three cases a father and five children are all employed by the company.

In common with other basic industries, long continued service in mining, particularly if carried on through several generations, has a marked tendency towards the development of certain fundamentals of character peculiar to that type of endeavor. Descending from the original hard-rock miners who first undertook to wrest the mineral treasures from a reluctant earth under most primitive conditions and continued for long periods in similar lines of work, the copper country workmen have developed exceptional qualities of industry, patience, perseverance and self-reliance. These qualities and the long engendered habit of steady attention to duty have earned for them the preferential rating they now enjoy in most industrial centers of the Middle West. It is necessary to make this reference to the unusually long service records and the splendid character of the employes to be able to appreciate the spirit of confidence and cooperation evidenced by both the employer and the employe.

Promotions are made as far as possible from within the organization, personal contact is fostered through heads of departments and employes are encouraged to bring any grievance direct to the management where sympathetic consideration is given each case. Any evidence of paternalism is avoided and no attempt is made to control or direct the private life of the employe except where his actions may be considered detrimental to the common welfare. Life and property are safeguarded by ample police and fire-fighting departments supplementing similar departments maintained by the neighboring incorporated villages.

With full appreciation of its dual responsibility to capital and labor, the management has taken a liberal attitude in relation to expenditures tending towards the betterment of living conditions for employes and the community in general. Wages have been kept on a comparatively high scale, working conditions have been made as pleasant as possible and working hours fixed in harmony with those of similar industries. Provision has been made for comfortable home life, a high standard of living is encouraged and an active interest taken in the well-being of all connected with the industry.

The community is far removed from the general conception of a mining camp. It is a progressive, up-to-date, typical American community with a stable population, affording opportunities equalled by few districts of comparative size.

The advanced philanthropic policy and high standards of business ethics instituted by its founders and continued by succeeding managements have resulted in a splendid spirit of confidence, cooperation and loyalty.

COST ACCOUNTING and METHODS

By A. D. Nicholas*

THE cost accounting method used by the Calumet and Hecla Consolidated Copper Company probably differs little from that of the mining industry in general, although it may vary in some of the details of its application. The standard practice is followed of dividing the operation into its several phases from the breaking of the ore in the mine to the refining of the copper and casting it into shapes for delivery to customers, and of recording in detail the items of labor, material, etc., charged to each of those phases. Thus there is secured monthly a record of the operation showing the results in quantity of copper produced and cost per pound in each and every phase, with all of the allied production and efficiency data.

However, the value of cost records lies not in the mere fact that they inform those interested as to the results of past performances, but rather that they provide information on the basis of which future costs may be estimated. Production costs can be reduced to a minimum only when the burden in this regard is assumed by all who share the responsibilities of the operation. Cooperation between management and operating force is essential, and this cooperation can become practical only when all information relative to those costs and on the basis of which they may be kept within bounds is made available to all interested parties. Moreover, it is vital that this information be provided at the earliest possible moment. Unusual items of expense constantly tend to creep in, and unless they are in some manner brought almost immediately to the attention of those responsible for the success of the enterprise, they are likely soon to be regarded as regular and legitimate. Calumet and Hecla has endeavored so to develop its system as to meet these conditions.

In endeavoring to control the production costs of a large industry, it is futile to view only the total cost. Abnormal items, large in themselves in relation to the phase they affect, become lost in the greater total of the entire operation. A small unit for cost accounting purposes is necessary and mining lends itself to this favorably, for the individual shaft is the natural unit of operation. Calumet and Hecla operates on three distinct lodes and through some 20 separate shafts, but the individual shaft with its contributory ground constitutes the definite unit and conducts its own operations from the breaking of the ore in the mine to the delivery of it to the crushing plant on the surface. It may, it is true, draw upon a common power plant for air, steam or electricity; it may be served with its supplies from the same warehouse as other shafts and look to the same shops for its repairs; nevertheless, it is a distinct entity operating to a large extent as a separate producer and having its own peculiarities as to conditions and problems. It is, therefore, highly desirable that it has its own cost accounts for comparison with previous records and with the records of others. To accomplish this there has been established the compiling of a daily record of costs for submission to the foreman in charge of each shaft and covering the unit's operation. For this purpose there is submitted to the accounting department, which naturally acts as the agency for the accumulating, computing and dissemination of the data, detailed information covering the charges against each unit; this consists of the direct labor as reported by the various timekeepers, indirect or distributed labor as coming from the shops, motive power department, etc., supplies delivered from the warehouses, and charges for air, steam and electric power; added to this is the record of the tonnage production from each unit, together with such other information as may be required in the computing of cost and efficiency data. The accumulating and tabulating of these records with the resultant computations necessarily constitutes a task of considerable proportions, but calculating the results and placing them in the hands of those interested with such little lapse of time as to retain their practical value is made possible by the installation of a set of electric tabulating machines especially designed for such work. As the information is received daily from the various sources it is transferred onto a set of specially printed cards by means of an electric key punch and then verified, again by machine, to eliminate possible errors. A sorting machine sorts the cards into the various shaft units, after which an electric tabulating machine automatically accumulates all information previously punched into the cards and transmits it to a printing head which types the accumulated data on printed forms. This typing having been done through a ribbon treated with copy ink, by means of a gelatin duplicator sufficient copies are produced to supply each foreman interested. As, in addition to the total costs, the sheets show the tonnage produced, cost per ton, and tons per shift, the foreman is furnished with data showing the efficiency of the day's operations, not only of his own shaft but, for purposes of comparison, of all others on the same lode. And this is done within the remarkably short period of eight hours from the close of the working day.

Supplementing the daily report, there is similarly issued a weekly report giving the same information but detailed to show the cost of each phase of the operation. This detail is available daily, however, to anyone whose total costs appear out of line and who wishes therefore to analyze it for the purpose of locating the disturbing item.

To assist in visualizing the results and trends, the weekly data for the three lodes is platted on a graphic chart.

As costs beyond hoisting run more uniformly day by day, the daily and weekly costs are compiled only for the underground operations. The monthly cost sheet of the company, which "sheet" is in reality a loose-leaf book of over 100 pages, is composed of statements covering all phases of the operation to the placing of the refined copper on the dock. With reference to the underground operations, it goes even more fully into detail than the weekly reports, and for certain purposes the longer period has its advantages in making comparisons or tracing trends. Similar detail is shown for each phase beyond mining, including crushing, transportation, milling, leaching, flotation, smelting and refining, together with the entire reclamation process. Each phase is shown fully in its various subdivisions, and these statements, with the supplementary tables of data on tonnage, cost and efficiency, all arranged in logical order, constitute a cost flow sheet which presents a complete picture of the production process.

The cost sheet also includes complete and itemized statements with reference to the operation of each shop and the production of power of all kinds—air, electric and steam. Since these costs are distributed mainly to the operating accounts in proportion to service rendered, the foremen in charge of which are held responsible for the total costs of their departments, the latter are naturally interested in seeing that these charges are maintained as low as possible. Consequently there is pressure brought to bear upon those in charge of the distributed operations which tends to hold the cost of same to a minimum. In order that the fullest information may be available to each one responsible for any phase of the work, each foreman is furnished with a copy of that portion of the cost sheet representing his department. Thus he is led to feel that however remote his department may be from sharing in the actual physical production of the copper, he controls one of the vital factors in the process and the cost.

To the production cost of copper through the refinery, the company adds selling, delivery and administrative expenses, and reports the results to its stockholders on a "cost sold" basis. For purposes of taxation, depletion is computed on the basis of values as determined for that purpose by the Treasury Department of the United States as of March 1, 1913, which values are greatly in excess of the cost of the property to the original stockholders. For the same purpose depreciation is computed on its existing plant, a large part of which was installed decades ago and paid for out of the earnings of former years. Therefore, in reporting its earnings, the company shows first its operating profit, after which the depletion and depreciation allowances as stated are deducted.

* Secretary and Treasurer.

SAFETY ORGANIZATION

at Mines 2 and 3

*of the Utah Fuel Co.**

By. D. J. Parker†

THE Utah Fuel Co. operates four coal mines in Utah—Clear Creek, Sunnyside, and Mines 2 and 3 at Castle Gate. At present, production has been considerably curtailed at the first two and the fourth mentioned. Castle Gate 2 is decidedly the largest producer, employing, after the regular seasonal reduction in personnel, approximately 200 men. Its daily output is 3,000 tons.

Mine 2 is opened on the Castle Gate D bed, which averages 24 ft. in thickness and dips north on a 10 percent grade.

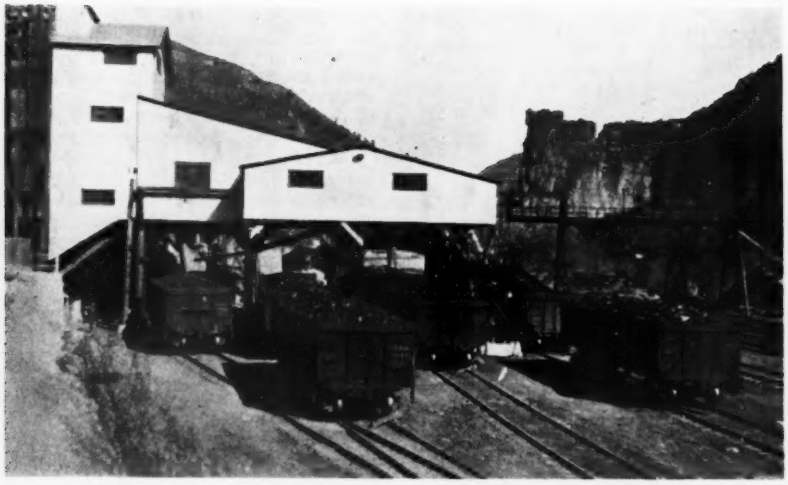
Owing to the adverse natural conditions prevailing in this mine, such as the abnormal height of the coal, thickness of cover with resultant bounces, pitch, methane liberated, and the highly inflammable characteristics of the coal-dust, Mine 2 has been considered one of the most hazardous in the West.

Under new management, safety has been made a major operating problem, and this mine is fast losing its previous unenviable reputation.

Castle Gate 3 is likewise operating on the D bed, which varies from 4 to 9 ft. in thickness. While the natural conditions are more favorable than in Mine 2, the same precautionary measures with respect to safety are employed as in the latter mine.

All open, accessible workings in these mines are thoroughly rock-dusted, and all abandoned sections are substantially closed off with fireproof seals.

Every working place is rock-dusted to within approximately 20 ft. of the face, and the nonrock-dusted face zones are kept wet. Water is applied freely to all cutter bars, and the coal pile sand ribs near the face are sprinkled to such an extent that a minimum amount of coal-dust is thrown into suspension during the process of winning the coal.



Number 3 Mine Tipple, showing Castle Gate Rock in the right background

* Reprinted from U. S. Bureau of Mines Information Circular. (Not subject to copyright.)

† District engineer, U. S. Bureau of Mines Safety Station, Salt Lake City, Utah.

Since the new management assumed charge of these properties, as of January 1, 1930, there has been a material reduction in accident rates, and during that year compensation costs were reduced $36,000.

It has been fairly definitely proved that the indirect cost of accidents, which includes the difference between the compensation award and wages, extra home expenses, lost time around the mine, expense of replacing the victim, the price of a shattered morale, damage to property, and other factors, is about four times the direct cost, therefore, in addition to the saving of $36,000 in compensation, there should have been, and no doubt was, a saving both to the company and to the men of approximately $144,000, or a total saving of about $180,000 during the period mentioned.

The company has for some time held monthly safety meetings for the bosses. Policies pertaining to safety and accidents that may have occurred during the previous month are discussed in detail.

While such meetings produce excellent results in curtailing accidents, the management felt that in addition to the foremen's meetings, still better results might be obtained by holding monthly safety meetings for all the employes at Mines 2 and 3. Attendance is compulsory both on the part of the foremen and the men. It is understood, however, that little or no pressure has been required. The average attendance at these meetings, which are held on the first Tuesday evening of each month, exceeds 200.

The officers of the general safety meetings are the chairman and the secretary. The chairman serves one month and is elected by majority vote of the rank and file; foremen are not eligible for this office; however, shot firers, fire bosses, and any employe other than foremen are eligible. The secretary is appointed and serves indefinitely; foremen are eligible for this office.

Six committees are appointed by the chairman to serve one month or more; foremen do not serve on these committees. The committees are as follows: (1) Outside, 3 men; (2) haulage, 4 men; (3) ventilation, 3 men; (4) rock-dusting, 3 men; (5) hand loading, 3 men; and (6) mechanical loading, 3 men.

The function of these committees is to make verbal reports at the meetings of any unsafe practices or unsafe conditions observed by them at any time during the month.

The committees receive no remuneration for their services, hold no meetings, and take no time off for their inspections. The personnel is so distributed throughout the mine and on the surface that the members are able to make all necessary observations during the regular course of their work. Each committeeman makes an independent report at each regular monthly meeting.

There is no fixed rule for dealing with absentees without valid excuse. The writer has attended five of the meetings held since January 1, 1931, and, so far as known, it has not been necessary to discipline any one for nonattendance. Should a reprimand prove ineffective for failure to attend, in case of chronic absenteeism, discharge would unquestionably follow.

Keen interest is manifested on the part of the men, and the number and variety of conditions reported by the various committeemen is surprising.

Not infrequently many unsafe conditions, perhaps of a minor character, are reported which have escaped the foremen's attention. However, if any unsafe conditions are observed that require immediate attention, such matters are reported at once to some one in authority.

A further duty of the committees is to investigate all accidents that come within the scope of their authority; for example, the haulage committee investigates all haulage accidents. A verbal report on all accidents is made by the various committees at the regular meetings.

The company officials make a separate written report for the purpose of determining responsibility, planning possible prevention of future similar occurrences, and studying such lessons as may be learned from these accidents.

It is the duty of the secretary to keep accurate typewritten records of all the proceedings of each meeting and to read such minutes at the opening of each succeeding meeting. One copy of the minutes is forwarded to the president of the company at Salt Lake City, and one copy is retained by the superintendent.

The order of business is:

1. Reading of the minutes of the previous meeting.
2. Reports of committees and discussions.
3. Discussion of all accidents occurring during the previous month.
4. Opening meeting for general discussion and safety suggestions.
5. Invitation to visitors to make talks on safety.
6. Appointment of committees by the chairman for the ensuing month.
7. Election of chairman for next month.
8. Roll call.
9. Adjournment.

It is customary for the superintendent to sit with the chairman to give any assistance needed. Accounts of all accidents occurring during the previous month are read by the superintendent, and as each one is read those men most familiar with the occurrence are called on for constructive criticism.

All matters discussed must pertain to safety, and the writer was impressed with the strictness with which this policy is carried out. As an illustration, in some sections of Mine 2 the diggers must deliver their own coal to the sidetrack. Upon the suggestion by a digger that the company furnish a driver to take their coal from the face to the sidetrack, the chairman promptly met the suggestion with the statement that these meetings were held solely in the interest of safety, and not for the purpose of discussing grievances.

At the outset, the officials of the company assured the men that any suggestions they might make for the promotion of safety, regardless of whether or not they reflected on the management, bosses, or individual workers, would not either prejudice the officials against the men or jeopardize their good standing with the company. As a result, discussions are open and above board, and occasionally committee reports may tend to reflect on the bosses as well as on the individual worker. Such reports are accepted without prejudice, and remedial measures are taken forthwith.

The fact that the men feel that they are being consulted regarding matters of safety apparently aids materially toward promoting friendly cooperation.

As a result of the intensive safety campaign now being waged by this company, Mine 2, as of June 4, 1931, had operated 89 days without a single lost-time accident.* On that date a trackman struck his finger with a hammer and caused a compound fracture. The time lost was 30 days.

As of June 30, 1931, the outside operations at this mine, including tipple, shops, and other places, employing about 60 men, have not had a lost-time accident for the past 159 days, and as of the same date, Mine 3, employing on an average 30 men, has not had a lost-time accident for the past 141 days, either above or below ground.

The president and other officials of the Utah Fuel Co. are among the pioneers in mine safety, and it is believed that a large measure of their success in curtailing accidents in Castle Gate Mines 2 and 3 is due to their ability to diffuse the spirit of cooperation and a safety consciousness throughout the entire organization. This result has been accomplished largely by intensive supervision, 100 percent first-aid training, monthly mass safety meetings, monthly foremen's meetings, and lastly and of paramount importance, by the earnest desire of the president of the company to keep accidents to the irreducible minimum.

* A lost-time accident is one where the employe, as a result of the injury, fails to return to duty the day following that on which the injury was sustained.

MAINTAINING DISCIPLINE

THE TEN COMMANDMENTS OF BUSINESS

By Thos. G. Fear*

TO A great many people the word "discipline" is quite unpleasant, and usually recalls memories of penalties incurred for doing the things they desired to do, but which, according to some higher authority, was not the proper procedure.

Discipline is one of the very fundamentals of our civilization, and is simply our mode of living according to instructions. From the time of the Veeda, Koran and Bible to our present city, state and Federal laws human beings have had instructions to guide and direct them in their actions.

Discipline, as related to coal mining, therefore, requires that those in authority formulate certain instructions pertaining to our mode of living in and about the mines, and in order that these instructions shall be the proper instructions, it is absolutely necessary that the persons formulating the instructions are themselves amenable to discipline, and also have the proper experience.

The executives and supervisory forces should keep in mind and obey the present day Ten Commandments which have been assembled by Col. M. C. Rorty, vice president of the International Telephone & Telegraph Company:

1. Definite and clean-cut responsibilities should be assigned to each executive.

2. Responsibility should always be coupled with corresponding authority.

3. No change should be made in the scope of responsibilities of a position without a definite understanding to that effect on the part of all persons concerned.

4. No officer or employe occupying a single position in the organization should be subject to definite orders from more than one source.

5. Orders should never be given to subordinates over the head of a responsible officer. Rather than do this the officer in question should be supplanted.

6. Criticisms of subordinates should, whenever possible, be made privately, and in no case should a subordinate be criticized in the presence of officers or employes of equal or lower rank.

7. No disputes or differences between officers or employes as to authority or responsibilities should be considered too trivial for prompt and careful adjudication.

8. Promotions, wage changes and disciplinary action should always be approved by the officer immediately superior to the one directly responsible.

9. No officer or employe should ever be required, or expected, to be at the same time an assistant to, and critic of, another.

10. Any officer whose work is subject to regular inspection should, whenever practicable, receive the assistance and facilities necessary to enable him to maintain an independent check of the quality of his work.

Successful business managements have been using these instructions for years and the concise manner in which Colonel Rorty has laid down these Ten Commandments should impress them indelibly upon our minds.

With the supervisory forces in the proper frame of mind to enforce discipline, the next requisite is the formulation of the instructions or rules.

This matter must be handled very carefully and each department should be requested to draw up tentative rules covering the department.

These department rules must next be combined, and all conflicting rules eliminated after which the resultant set of rules should be passed on to each department for correction and ratification.

Our own experience in formulating a set of safety rules for 47 mines operating in ten different coal seams in four different states demonstrated the advisability of this method of procedure. Rules set up which are not enforceable detract from the degree of enforcement of good rules.

The best example of this is the disregard of many state and federal laws since the passage of one Volstead law.

Education—The next step after the rules have been made is to educate the men so that they may all have a working knowledge of what is expected from them. Our plan is to have schools for our supervisory forces and when these men have passed a satisfactory examination they in turn instruct the men in their departments.

Penalties—A uniform system of penalties must be set up to insure fair and impartial treatment to all violators of rules although it is impossible to fix the penalty for each and every offense. Our system provides for a warning for the first offense; two days' suspension for the second offense; ten days' suspension for the third offense, and discharge for the fourth offense. For flagrant cases of violations of the safety or coal preparation codes, the offender may be discharged for the first offense when in the judgment of the mine superintendent the violation was premeditated and intentional.

All the officials of the company are subject to these same rules and superintendents and mine foremen have been suspended and in some cases discharged for violating the rules. Not even the president and vice president are exempt as the records of our Safety Courts show fines have been collected from both.

When the offense is noted by a member of the supervisory force, a discipline report is immediately made out and forwarded to the mine office.

A card index file on each employe is kept at each mine, and also in the divisional headquarters, where all violations and penalties are recorded. From this mine file the superintendent can determine the number of the offense which automatically sets the penalty, except in special cases.

Each offense is carried on the record for a period of 12 months, after which it is dropped and the record cleared.

It was our belief that in fairness to the employes, the records should be cleared periodically in order that slight infractions of the rules a year apart would not cause suspension or discharge.

Each employe has the right to appeal to the division personnel manager who investigates the case and if he believes the man was not treated properly, the entire case is referred to the division manager for settlement.

Fairness and firmness are the two essential requisites in a foreman or superintendent to enable them to mete out proper discipline, and many intelligent and honest men have failed in handling men because they lacked the necessary nerve to do the thing they knew ought to be done.

The success of a discipline system depends entirely on how it is received by all and, when the employes believe they are being treated fairly and without partiality and that they themselves can have the supervisory force disciplined through fines imposed by our Safety Courts, there is no resentment.

Cleanliness of the mining towns, plants and underground workings has a very decided effect upon discipline; where the mine management keeps the plants in a tidy and orderly manner, the men naturally form better habits. This same effect is also noted that where the safety discipline is strictly enforced, it is much easier to enforce preparation of coal rules or any other efficient operating rules.

To summarize this subject in a few words, set a good example, be fair and firm and you will get results.

* General Manager in Charge of Operations, Consolidation Coal Company.

MAINTAINING DISCIPLINE

JUSTICE
AND
EDUCATION

DISCUSSION BY

Milton H. Fies*

I AM in complete accord with the splendid suggestions made by Mr. Fear. Frankly, I know of no one in this entire country who is better qualified to speak about matters relating to safety than is he. This statement is based on a knowledge of results that he has obtained.

I agree with Mr. Fear that it is absolutely necessary for persons formulating instructions to be themselves amenable to discipline. If the safety movement in the coal mines of the United States is to improve to the extent that the severity rate will equal that of such foreign countries as Great Britain, France, or Belgium, the *impetus* must come from the top. For this movement to be a complete success, the chief executive officers of the operating coal companies of the United States must interest themselves vitally in safety, and by this I mean they must manifest more than a casual interest.

A few years ago the industrial world was more or less startled by the statement made by a representative of the Travelers Insurance Company to the effect that over 90 percent of the industrial accidents in the United States were preventable. This is tantamount to saying that 90 percent of accidents are the result of carelessness.

The synonym for carelessness is thoughtlessness—the remedy or antidote for thoughtlessness is thinking. Consequently, it may be justly argued that if men could be taught to think, a great many accidents would be eliminated.

Up to this point I think we are correct in our reasoning. Now, let's get away for the time being from such safety measures as timbering, clearances, etc., and go to a seemingly abstract subject.

Psychologists tell us that the intelligence of the average person in the United States is that of a boy of about 15 years of age. I think it is fair to accept this statement of scientists as correct. If we do this, it would be reasonably accurate to deduce that the average intelligence of a class known as coal miners would be that of a boy of 12. Therefore, as I see it, the problem of the safety director or the engineer, or the executive officer of a coal company is to follow such measures in regard to safety as would impress, or teach, a boy of 12 to think.

It is self-evident, eliminating the aspect of so-called learning, that mentally alert individuals think more readily than those who are more sluggish. In my opinion, it is only a question of time until the processes of education are permitted to work out man's destiny, that employers of labor are going to subject applicants for work to tests for mental alertness. Please do not misunderstand me. Industry does not expect to entirely deprive banking houses of their bond salesmen by employing only college graduates. But industry, by simple psychological tests, is going to weed out sluggish, slow-thinking, indifferent workmen—and when they do, accidents are going to be reduced. It would be an interesting experiment, I am sure, for some of our larger, more progressive coal companies to devise some simple test for mental alertness and employ in, say, one mine, of average hazards and supervision, men who pass this test; then compare the accident record of that mine with other mines operated by the same company with somewhat similar conditions that do not have the test. There is nothing new about this idea. I understand some few of the larger industrial corporations have tried this experiment in plants where the hazards are more or less man-made. My judgment is that the results would be more marked where there are natural hazards fixed and established by nature, as in coal mines.

The question naturally presents itself what would become of the thousands of men whom these tests would eliminate from the coal mines? The answer is that such men would probably obtain employment in less hazardous occupations. This, too, I think would follow—proving in the end an unalloyed blessing: Men who lose lucrative employment because of mental torpidity will naturally turn for help to the educational facilities of the country that their children may not also be penalized. It is a fact that lack of mental alertness may be largely overcome by training.

I think that most of us, when we were growing up, rather resented the word "discipline." I am sure that the boy of 12 resents discipline because of the implication of the word. Two of the synonyms of discipline are coercion and punishment, and I am convinced that this is the first interpretation that the average worker places on the word "discipline." Order, instruction, and drilling are likewise synonyms of the word, and, in our relationship with our employes in accident-prevention work, we should emphasize the interpretation of the word "discipline" as meaning training and instruction. If we do this, it will be very much easier to maintain discipline than if we interpret and stress the word in the sense of coercion or punishment.

I am sure that Mr. Fear, the author of the paper on "Maintaining Discipline," has appreciated the psychology of accident prevention. In his Accident Court, which has been an innovation in this type of work, he has sensed the necessity of maintaining interest among employes who have not had educational opportunities. He also has appreciated, I know, judging from the opening paragraph of his paper, the unfortunate interpretation that might be placed on the word "discipline," or the impression it very likely conveys to the minds of the average coal miner.

I hope that no inference will be gathered from this presentation that we can afford to assume those measures which have been adopted and which have brought credit to the industry along safety lines should be neglected, and a turn made to an approach exclusively to the subject along the lines suggested. I only present the matter as one for thoughtful consideration, with the hope that it might some day lead to an Utopia in accident prevention as a part of industrial relationship.

Those fundamental principles of safety, based on intelligent supervision, discipline in the nature of instruction, and education in safety measures, must never be neglected.

It is my belief that in maintaining discipline, until we work out many other measures that will assuredly be developed, we should base this discipline on a fine sense of justice rather than on coercion or punishment.

* Vice President in charge of operations, Debardeleben Coal Corp.

Practical Operating Men's Department

METALS

Due to the cooperation of Mr. Guy N. Bjorge in the preparation of the articles on the operations of the Calumet and Hecla Consolidated Copper Company, which appear in this issue, the Metals Section of the Practical Operating Men's Department is omitted.

MAINTAINING DISCIPLING

LAW AND INDIVIDUAL RESPONSIBILITY

DISCUSSION BY

I. N. Bayless*

SOME of the definitions of the word "maintain," as given by Webster, are: Holding or keeping in particular state or condition; to support; to sustain; to assert; vindicate.

The same authority defines the word "discipline" as meaning: Training to act in accordance with established rules; subjection to rule; submissiveness to order and control; habit of obedience.

There are probably as many different opinions as to the method of maintaining discipline in the coal industry as there are managers, superintendents, and foremen at the different operations.

In all well-managed organizations today the higher officials have given a great deal of thought to formulating rules to guide each man in his particular position or class of work.

This is no small job, as the management does not want to destroy the initiative ability of the men in his organization.

The management of the Union Pacific Coal Company and the Washington Union Coal Company gave a great deal of time and thought to formulating the rules and specifications contained in their "Code of Standards," printed October 1, 1927, and the book of "Rules and Regulations for the Government of All Employes of the Union Pacific Coal Company," published and distributed November 15, 1929.

We read in the "Code of Standards," under the head of personal conduct, the following:

"The work of mining coal constitutes a reputable business; providing that the men who work in and about the mines maintain a proper measure of responsibility, good character, and self-respect. This rule applies to the working force; to the directing force it applies double.

Forty years ago the term "railroad man" was synonymous with "recklessness"; a recklessness not only expressed through the personal habits, conduct, and speech of the individual but also in the clothes that many railroad men affected; "box-toed" boots, black braid trimming on the edges of coat and vest, including all pockets. A "spring bottom" or wide flare at the bottom of the trouser leg likewise went far to make an embryo railroad man the real thing.

The term "Safety First" had not been coined 40 years ago; as a matter of fact, the theory of the safety movement in railroad work was developed through the efforts of a man entirely outside the railroad service. Forty years ago good society looked askance at the railroad man; not so today; he now constitutes an army, 1,750,000 strong, of the most respected, intelligent, and law-abiding citizenry we have.

There has always been a close relationship between the work of moving trains and the mining of coal. Both tasks call for men of good, robust physique, alert minds, and a high order of physical courage. Both occupations are in the hazardous class. At one time the chances for death or disability were about equal in the two industries. Within the past decade the railroad industry has been made one of the safest industrial occupations—the coal-mining industry has hardly held its own. Personal conduct and the existence or the absence of an adequate sense of responsibility enter heavily into the conduct of all worldly affairs.

The conditions surrounding the operation of the properties of the Union Pacific Coal Company and Washington Union Coal Company fully justify the belief of the management—

First: That the overwhelming majority of our employes believe in the observance of all Federal, State, and municipal laws, and in maintaining a general high standard of personal conduct.

Second: That the existence of gambling houses and other places of vice, including the manufacture and sale of intoxicating liquors, is definitely wrong, working a serious injury to the younger people as well as those who participate in same.

Third: That a job that is worth having is worth keeping, and that the obligation on the part of the employe to render a conscientious, continuous service is equally binding with the obligation of the employer to pay an adequate wage, to make the work as safe as possible, and in a general way to look after the welfare and the happiness of his employes, this without attempting in any way to interfere with their personal freedom.

Believing, as we do, that it is only the few who do not by preference maintain a reasonable standard of sobriety, industry, and morality, then it reasonably follows that this minority who prefer to go their own way should undertake to exercise the license they desire elsewhere, finding residence and employment in a more congenial atmosphere.

In making this presentation it will be understood that employes occupying official positions, or in any way charged with the direction of the property or the working force, have a double responsibility in the direction of good conduct, of courtesy to other employes, and in the full observance of all lawful regulatory measures. *Men who do not maintain a reasonable standard of conduct will not be continued in the service of these companies.*

A copy of the Code of Standards is given to the supervisory officials and contain instructions and specifications for handling, installing, and maintaining machinery, electrical equipment, tracks, wires, and handling explosives, first aid, safety lamps, inspection of equipment, etc.

A copy of the "Rules and Regulations" is given to each employe; it contains:

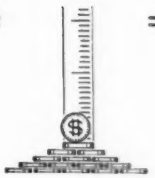
1. Purpose of rules.
2. Duty of employer.
2. Duty of employes.
3. Conditions of employment; rules and regulations.
4. Mine foremen and assistants.
5. Gas watchmen.
6. Shot firers.
7. Shooting wire.
8. Sprinklers.
9. Boss drivers.
10. Drivers and snubbers.
11. Rope runners.
12. Motormen and motor brakemen.
13. Timbering.
14. Miners and loaders.
15. Machine runners and helpers.
16. Hoisting engineers.
17. Master mechanic and chief electrician.
18. Pump men.
19. Stable boss and assistants.
20. Mechanical loading face employes.
21. Miscellaneous regulations.
22. Rules covering handling of explosives.

Under the heading of "Purpose of These Rules," we read the following:

"The management of the Union Pacific Coal Company has in the past five years made extraordinary expenditures in labor and material, to further the safety of our employes. Extensive additions to the supervisory and safety staff have also been (*Continued on next page*)

* Assistant General Manager, Union Pacific Coal Co.

MAINTAINING DISCIPLING



WAGE SCALE

DISCUSSION BY

John H. Richards*

THE payment and acceptance of money for services rendered is one of the most important, if not the most important, transaction made by man. A *satisfactory* transaction of this kind is vital to the success of any industry. It *must* be satisfactory to both parties to be successful. The individual must be satisfied with the amount received in order that he and his family may enjoy life in keeping with their standards. The industry must be satisfied with the amount paid so that a reasonable profit is assured.

It is practically impossible to gather together an organization of workers who when working individually will produce an equal amount of labor in the same period of time. For this reason, any fair method of payment must be based upon the fact that the individuals concerned are not all physically equal.

This inequality of men caused the piecework method of payment to spring into existence. The results of the piecework or tonnage method of pay in coal mines have been inefficiency and insubordination. The loaders got to the place where they practically came and went to and from their work as they pleased. Some were satisfied with a certain daily tonnage and would not work after that tonnage had been loaded. This condition resulted in a much higher cost than was necessary. To combat the evils of the tonnage system, establish more rigid discipline, and still be fair to all, the Hanna Coal Company has worked out a plan of payment which is based on a graduated day rate basis. We will endeavor to outline to you the plan decided upon and its practical application.

This wage scale embodies the Ohio wage scale adopted August, 1927, where it applies. All other rates which apply to modern methods adopted since August, 1927, are based on the Ohio wage scale rates.

In order to establish a fair day rate for the loaders who formerly worked on a tonnage basis, time studies were made. An analysis of these time studies proved that if the coal were sheared and the loader relieved of the work of drilling and shooting and track laying, a loader would average 13 tons of coal per day in place of 8 tons under the old system.

Inasmuch as under this system the company furnishes the powder, thereby relieving the miner of this expense, a base rate of $5.20 per day, based on 13 tons of coal, was adopted, and this rate was graduated up to $10 per day for 20 tons of coal and down to $4 for 10 tons of coal. The graduations under the base rate were put in to take care of the men who were old both in age and in years of service or who from other physical weaknesses would be unable to maintain the base tonnage.

Under this system the loader is relieved of the work of drilling, shooting, and laying his track. The coal is sheared, which also facilitates the loading and relieves the loader of quite a lot of pick work at the back of the cut. The loader is required to load and clean the coal, gob the draw slate, post his place, and push his car one way.

At the end of the pay period the average tonnage for each loader is worked up and the average daily tonnage is used to determine the rate per day for that pay. Any tonnage or fractional tonnage in excess of the amount used in striking an average is carried over and used in working the rate for the following pay.

Cutting is all done with Oldroyd universal cutting machines. The cutters are paid a minimum rate of $7 per day. The cutters' tonnage is also averaged for his pay to determine the day rate payable. The cutters are paid 50 cents for each 20 tons, daily average over 280 tons. All of our cutters are making over the minimum day rate.

The men are required to spend a full eight-hour shift at the face. If any employe is not at work without first securing permission or sending word in case of sickness, that man, of course, is docked for the day and, as a further penalty, the day, in the case of machine men or loaders, is counted in figuring his average tonnage per day to establish his day rate for the pay.

At two mines where this system is in effect there were only 8 loaders whose average was under 10 tons for the pay period ending March 31. There were 81 loaders whose average daily tonnage was from 10 to 13 tons, and 204 men whose daily average was over 13 tons. For this same period the average day rate for all of the loaders was $5.80.

By the use of this system, it has been possible to increase the earnings of the cutters and loaders 10 percent, and at the same time reduce our cost 18 percent.

* Chief Mining Engineer, Wheeling & Lake Erie Coal Mining Co.

MAINTAINING DISCIPLINE, by I. N. Bayless

(From previous page)

made—all without apparent tangible result. We are, as a result of this situation, led to believe that mine employes have acquired the feeling that the effort made by the company is sufficient to insure their safety. The accident record does not bear out this belief. There are certain elements of accident-prevention work that rest almost wholly with the company and its officials; such include the proper condition of equipment, an adequate timber supply, proper ventilation, rock dusting and a water supply to prevent dust explosions, etc. The overwhelming number of accidents, however, are of the class which indicates that the safety of the individual rests almost wholly with himself. No church organization is capable in itself of complete spiritual salvation; no law-making body can completely prevent crime; *likewise no coal company or individual can prevent mine accidents or even keep same within limits, unless each and every man undertakes to protect his own life and limb.*

"The purpose of these rules is to bring out the fact that the man who is to avoid accident must exert every personal effort to do so if loss of life and human suffering is to be reduced, and to point out to all employes, and especially to those who are inexperienced, the dangers incident to mining, so far as it is possible to do so in a set of rules, and also to present the precautions to be taken by both experienced and inexperienced men, in order that they may make their work less hazardous. The instructions contained herein deal only with the dangers common to mining in this field and are not to be wholly depended upon as covering all the dangers that attach to mining in its many peculiar and ever-changing phases.

"The advice and instruction of the mine foreman or his assistant should be sought when conditions not treated herein present themselves, or when more detailed instruction is required for the safety of the employe.

"In any case, where any question of conflict arises between the following rules and regulations and the laws of the State of Wyoming governing the operation of coal mines, or the code of standards of the Union Pacific Coal Company, the State laws and the code of standards shall govern."

Modern Mining with CONVEYORS in WIDE ROOMS and MODIFIED LONG FACES

By G. B. Southward

Conveyor mining in the year 1928 produced approximately 4,000,000 tons of bituminous coal—in the year 1930 this had increased to over 6,000,000 tons. The 1928 tonnage figures show that conveyors had become established as an accepted device for coal loading and the increase over the past two years indicates a steadily widening field of application. The real importance of conveyor mining, however, is not measured by its tonnage figures but rather by its development of new systems and new operating methods, such as long face modifications, concentrated room mining, successful roof action by supporting the top with small coal pillars or with steel jacks, mine car loading in trips, and multiple cuts during a shift in one working place.

Conveyor mining systems are following two trends—wide rooms and long faces. Both systems are advocated by men of experience, but the future will show that each has advantages for certain conditions. Room mining will undoubtedly develop along the lines of multiple units while long faces through further modifications and the use of steel supports will simplify the present roof problems.

Conveyor mining has just started—of that we may be very sure. Its present economies have been proven and its future progress will be furthered through the elimination of hand shoveling, either by self-loading conveyors or by combinations with mechanical loaders.

TWO reports are submitted with this article on conveyor mining with hand shoveling in wide rooms and on long faces. The reports describe only the mining on the faces and do not include the entry development or any of the panel operations. The figures therefore cannot be used as a direct comparison of mining by the two systems and are merely to show a comparison of the labor used in taking the coal from the solid to the main haulage.

These two systems require quite different operating methods. The long face mine makes only one cleanup during the shift while the wide room makes two cleanups requiring two complete cycles. Each operation has a face conveyor discharging onto a haulage conveyor which loads into mine cars, but the rooms are worked advancing while the long face is retreating. This means that in the room mining the haulage conveyor must be extended after each cut or twice during the shift while the long face does not shorten its haulage conveyor except periodically.

Both seams have about 6 in. of impurities which are removed at the working face, but their methods are quite different. In the room mining the machine cuts in parting and the bugdust is shoveled back into the gob. In the long face the parting is picked out by hand. A further difference between the two is in the height of the seam. The long face mine has a seam of almost 5 ft. thick while the room mine has a height of slightly over 3 ft.

The figures for the man hours per ton in these two operations have the items of labor following the same classifications with two exceptions. Mine No. 34 has a cost of .012 man hours for supervision which is not reported as a separate cost item in No. 21, while Mine No. 21 has a cost of .011 for conveyor maintenance which is not shown separately in Mine No. 34. In both mines, however, each of these classes of work are done. The supervision in Mine 21 is in charge of one of the crew members who acts as leader and the conveyor maintenance in Mine No. 34 is probably included in the item listed as miscellaneous.

Because of the fact that the organization of the crews is different in each mine it is not possible to say that the man hour figures in these reports represent the exact differences between the performance efficiencies of the various operating items at these two mines. For example, the loading in the long face work is 50 percent higher than in the room mining, but this figure includes the labor for mine car placement. Another item which needs explanation is the conveyor extension. This shows to be much less in the long face work than in the wide room but this is because the haulage conveyor in the room mining is lengthened after each cut while the haulage conveyor in the long face mining is shortened periodically and does not show as part of the regular daily work.

The one particular item of labor where the long face mine should have a distinct advantage over the room work is in the machine cutting. This seems to be borne out by the report which shows that the room mine requires over three times the man hours per ton as the long face. This comparison, however, is not correct as the following adjustments must be taken into account. The long face has the thicker seam and if we reduce both operations to a square foot of kerf basis we find that the wide room requires only 2.3 times as much labor for the cutting as the long face. When we further take into account that the wide room is cutting in the slate the actual difference in the labor between the two would be still further reduced, although the advantage would still be held by the long face mining.

Since there are different conditions in these two mines, and since the total man hours per ton are so nearly the same, it is not possible to judge from these reports which system has any marked superiority over the other. It is just as well that this is the case as it would be unfair to form any conclusions of this nature from only one example of each type of mining.

MECHANIZATION SURVEY of The AMERICAN MINING CONGRESS

THE AMERICAN MINING CONGRESS—MECHANIZATION DIVISION

Report No. 34—Conveyors On Long Faces

Distribution of Labor Employed

OPERATION	Man-hrs.	Man-hours Per Ton
Cutting	2.15	.025
Drilling	2.15	.025
Shooting	1.93	.023
Picking slate	1.77	.021
Loading and	19.55*	.225*
Car placement	*	*
Setting timbers	1.70	.020
Delivering timbers	1.33	.016
Conveyor extension	1.73	.020
Conveyor maintenance	—	—
Supervision	1.00	.012
Misc. labor	5.41	.063
Misc. delays	2.99	.035
Total	41.71	.485†

† In order to make these figures more directly comparative with other mines in clean coal the man hours are based on the total tons of material mined including coal and slate partings.

* Two operations by same crew.

— Not reported separately.

GENERAL DATA

Height of seam	4 ft. 11 in.
Partings	6 in.
Coal mined	4 ft. 5 in.
Working place	Long face
Width of place	80 ft.
Depth of cut	6 ft. (in coal)
Tons of coal per cut	78
Tons slate per cut	8
Total tons per cut	86
Cuts loaded per shift	1
Total tons per shift	86†
No. of men in crew	5
Drill holes per cut	14
Timbers per cut	60

EQUIPMENT

Length face conveyor	80 ft.
Length haulage conveyor	100 ft.
Total length conveyor	180 ft.
Cutting machines	1
Electric drills	1
Gathering locomotives	1
Rope hoists	1

THE AMERICAN MINING CONGRESS—MECHANIZATION DIVISION

Report No. 21—Conveyors in Wide Rooms

Distribution of Labor Employed

OPERATION	Man-hrs.	Man-hours Per Ton
Cutting	5.90	.080
Drilling	1.80	.024
Shooting	1.80	.024
Picking slate	2.90	.040
Loading	10.40	.140
Car placement	4.10	.055
Setting timbers	3.50	.047
Delivering timbers	1.00	.014
Conveyor extension	3.10	.042
Conveyor maintenance	.80	.011
Supervision	—	—
Misc. labor	—	—
Misc. delays	5.70	.077
Total	41.00	.554†

† In order to make these figures more directly comparative with other mines in clean coal the man hours are based on the total tons of material mined including coal and slate partings.

— Not reported separately.

GENERAL DATA

Height of seam	3 ft. 2 in.
Partings	6 in.
Coal mined	2 ft. 9 in.
Working place	Rooms 44 ft. Wide
Depth of cut	6 ft. 7 in. (in slate)
Tons coal per cut	31
Tons slate per cut	6
Total tons per cut	37
Cuts loaded per shift	2
Total tons per shift	74†
No. of men in crew	5
Drill holes per cut	8
Timbers per cut	20

EQUIPMENT

Length face conveyor	40 ft.
Length haulage conveyor	300 ft.
Total length conveyor	340 ft.
Cutting machines	1
Electric drills	1
Gathering locomotives	1 (for 3 units)
Rope hoists	1

SILVER RESTORATION

Urged by F. H. BROWNELL

ADDRESSING the Mineral Law Section of the American Bar Association at Atlantic City, September 16, Francis H. Brownell, chairman of the board of the American Smelting & Refining Company, urged the necessity of restoring silver the world over as a monetary metal and as a principal remedy for depression.

"All that is necessary," said Mr. Brownell, "is that the nations of the world retrace the steps taken since the war; that they stop any further demonetization of silver now in use; that they, individually or collectively or both, make it known that the further sales of silver by governments will cease; that the governments, while not establishing any fixed ratio between gold and silver, make clear their intention to resume the use of silver to the same extent as before the war.

"This automatically would restore silver. It automatically would preserve it for present and future monetary needs of the world. It would lessen the present burden of gold.

"The step is easily taken if the will to take it exists. It needs only cooperative action by the more important industrial nations of the world. Formal action in the shape of treaties is not required.

"If the British empire, France, Germany, Italy and the United States and Japan should substantially and simultaneously recommend the adoption of such a policy and should announce their intentions to act, the smaller nations of the world, seeing that silver is not doomed to abandonment but is to be continued in use, would rapidly adopt the silver policy. An international conference, formal or informal in nature, recommending such action would be of the greatest help.

"No one could reasonably maintain that the action above described would terminate the present world depression, the greatest and most far reaching in history. None the less sound and stable monetary systems are of paramount and fundamental importance in all nations."

MANUFACTURERS SECURE LICENSES TO USE "ZINC INSTITUTE SEAL OF QUALITY"

Galvanized sheets of certified quality, carrying a zinc coating much heavier than on the average commercial sheet, are now readily available to the consumer through completion of license agreements for the "Seal of Quality" trade-mark of the American Zinc Institute. The manufacturers who have been licensed to use this "Seal" upon galvanized sheets are the following: American Sheet and Tin Plate Company (subsidiary of United States Steel Corporation), Pittsburgh, Pa.; Continental Steel Corporation, Kokomo, Ind; Reeves Manufacturing Company, Dover, Ohio; Youngstown Sheet and Tube Company, Youngstown, Ohio.

The matter is under consideration by other manufacturers of galvanized sheets, including Apollo Steel Company, Apollo, Pa.; Bethlehem Steel Company, Bethlehem, Pa.; Granite City Steel Company, Granite City, Ill., and Newport Rolling Mill Company, Newport, Ky., formal completion of the license agreement being delayed by absence of some of their officials.

The "Zinc Institute Seal of Quality" has been adopted as an emblem for heavily coated galvanized sheets as an aid to the buyer in securing long service and durability. The need of such a guide to quality has been emphasized by recent field investigations of the Institute. These have shown not only a great variation in the zinc coatings on galvanized sheets installed at different times, but also a lack of knowledge of this entire subject on the part of consumers, dealers and even ditributors of such sheets. License to use the "Seal" is available to manufacturers without charge.

The Institute's specifications were adopted in conference with interested manufacturers, and prescribe a definite standard of 2 ounces of zinc coating per square foot. Originally a 1.75 ounce coating was also contemplated, but it was considered best to standardize on one weight of coating, which should be sufficiently heavy to assure satisfactory service in all cases. Special care is required in the manufacture of these sheets, and rigid tests and inspections are provided, both by the manufacturer and the Institute itself.

Montana Mines Corporation Acquires Property

Acquisition of a lease and option on the Franklin gold mining property, near Helena, Mont., by the Montana Mines Corporation has been announced. The Franklin mine is the property of the Thomas Cruse Mining and Development Company, of Helena, and was a valuable producer for many years, prior to 1918, when its crude ore averaged approximately $35 to the ton. Shipments were made to the East Helena smelter.

Gus Carlson, manager of the Montana Mines Corporation, stated that it is the purpose of his firm to explore the Franklin mine at once by diamond drilling from the surface, both in the old workings and on the new grounds, using steam power outfits. The property includes several claims with a combined area of about 250 acres.

The Montana Mines Corporation has operated the Spring Hill property, a low-grade gold mine three miles southwest of Helena for the last three years. In 1930 it was the leading gold producing center of the state.

Receivers For Seneca Copper Mining Company

Frederic R. Kennedy, president, and William F. Hartman, general manager, have been appointed receivers of the Seneca Copper Mining Company, Houghton, Mich. The total indebtedness is listed at $1,680,000, of which $1,482,500 represents outstanding bonds.

Stockholders Approve Phelps Dodge-C. & A. Merger

The acquisition of the assets and properties of the Calumet & Arizona Mining Company by the Phelps Dodge Corporation was approved by stockholders of both companies at meeting held September 21.

Phelps Dodge stockholders also authorized an increase in capital stock to 6,000,000 shares, $25 par, from 3,000,000 shares, and approved the change making the board of directors consist of not less than nine and not over 21 members.

The merger will be through an exchange of stock on the basis of 3¼ shares of Phelps Dodge for one share of Calumet & Arizona stock after the declaration of a cash dividend of $2.50 a share by C. & A.

Stocks of Refined Lead

Stocks of refined lead in the United States at the end of August showed a decrease of 2,876 tons compared with the end of July, amounting to 131,082 tons. This compared with 72,832 tons at the end of August, 1930, the American Bureau of Metal Statistics reported. Total refinery production of lead in the country in August amounted to 35,702 short tons, a reduction from the previous month, when 36,566 was produced and comparing with 58,036 in August, 1930.

Great Britain Increasing Consumption of Lead

Great Britain offers an expanding market for lead and lead products, having increased its imports under this class almost every year since 1924, when the total was 271,000 tons, according to the Commerce Department. In 1930 lead imports reached 380,000 tons, valued at about $30,500,000. Great Britain's almost total dependence upon imported lead makes import figures a reliable indication of its capacity for consuming this metal.

An analysis of the lead market of the United Kingdom is given in *Commerce Reports* for September 7, published by the Department of Commerce. It covers classes of imports and United States share, centralization of British lead trade, and indications of future trade. *Copies available through this office, 10 cents.*

UNEMPLOYMENT RELIEF MEASURES

PRESIDENT HOOVER'S organization on Unemployment Relief, now headed by Walter S. Gifford, of the American Telephone and Telegraph Company, is marshalling advisors from among industrial and welfare organizations. The purpose of this organization is to inspire local industries and communities to create additional avenues of employment and to organize local agencies for dispensing such relief as may be necessary in behalf of the six or seven million unemployed and their families. The President is opposed to the granting of "doles" to the unemployed out of the Federal Treasury, but believes that the unemployment situation can be solved by industry and by well-planned public works by the Government, and that relief for the unemployed is properly the function of local agencies. During the latter part of October a nation-wide appeal for funds for relief of the unemployed will be made under auspices of the President's committee.

"Industry and labor have cooperated splendidly in spreading and devising plans for splitting hours and dividing up the work in any given establishment among the employes in that establishment," says Fred C. Croxton, assistant director of the President's organization. "Another activity is providing work through public and private funds that would not be done at present except to meet the emergency. The President's organization is made up of a great number of leading citizens throughout the country and the work will be carried on through the state governors and state committees. There is no standard plan. Each state knows its own problem."

Utah Smelters To Reopen

The Murray smelter of the American Smelting & Refining Company, at Murray, Utah, will reopen on October 1 on a one-furnace basis, according to an announcement. At the same time it was announced by the International Smelting & Refining Company that its Tooele, Utah, smelter would also open some time in October.

The East Helena, Mont., plant of the American Smelting & Refining Company, resumed operations the middle of September with one furnace, requiring 200 employes. J. D. Mackenzie, manager, stated that an improved lead market and a reduction in surplus lead stocks made it possible to reopen the plant earlier than planned when operations were suspended on July 1.

Copper Stocks Increase

Stocks of refined copper increased 15,358 tons in August to 455,775 short tons as of August 31, the highest total in the history of the industry. The total, reported by the American Bureau of Metal Statistics, compares with 440,417 tons at the end of July and 347,688 tons at the end of August last year.

Stocks of blister copper declined to 176,105 tons during the month from 179,658 tons reported as of August 1.

Production of copper by the United States amounted to 38,925 short tons in August, compared with 38,228 tons in July, and 56,136 tons in August last year.

August shipments increased to 74,832 tons, from 69,465 tons reported in July. In August last year, shipments amounted to 95,129 tons.

World smelter production of copper in August amounted to 122,155 short tons, compared with 121,504 tons in July, and 154,743 tons in August, 1930, the Bureau announced. Since last March, when the output was 136,958 tons, production of copper has declined fairly steadily.

Cinnabar Discovered in Arkansas

The recent discovery of cinnabar (sulphide of mercury) which is the most important ore of mercury, at two points about 15 miles apart in Pike County, Arkansas, is announced by George C. Branner, state geologist. Prior to the late discoveries, the presence of cinnabar had never been reported in Arkansas. It is a remarkable coincidence that cinnabar from the two entirely separate localities was identified independently within a period of about two weeks.

The eastern Pike County cinnabar was first noticed in May, 1930, by D. F. Short, of Amity, while blasting out sandstone riprap on the Missouri Pacific Railroad one-fourth mile south of Nutt's Crossing, which is about five and one-half miles by rail south of Amity. The mineral was identified as cinnabar on July 20, 1931, by Moritz Norden, of Hot Springs.

The western Pike County cinnabar, according to the landowners, was first found about four months ago in section 1, Twp. 7 S., R. 26 W., by Crown Cox, a farmer living in that locality, and was identified by Walter F. Hintze, of Murfreesboro, during the second week in July, 1931.

Treasury Deficit Makes Taxation a Live Subject

The continued deficit in the Federal Treasury, caused by an excess of expenditures over receipts is worrying the President, the Secretary of the Treasury and members of Congress. The deficit has arisen because of two causes —decreased income taxes due to the business depression and large appropriations of Federal funds by Congress. Congress has found that it is difficult to resist appeals for appropriations and in the absence of a sharp reduction in Federal appropriations, must provide the money to support the Government through added taxes. Senator Glass, of Virginia, has suggested that two billion dollars may be cut from the five billions usually appropriated for the Government services, and Representative Wood, of Indiana, has suggested that appropriations for the Army and Navy be cut in half. Secretary of the Treasury Mellon has suggested that the tax base be broadened by decreasing exemptions now allowed taxpayers so as to bring more people in the tax paying class. Senator Reed, of Pennsylvania, has suggested a sales tax and Representative Bacharach, of New Jersey, has proposed an increase in the tax on incomes in excess of $100,000.

At the present time the chief activity of the Joint Committee on Internal Revenue Taxation of interest to mining is the study of the depletion deduction taken in arriving at net income upon which tax is paid.

The research of the staff of the Joint Committee issued a preliminary report on depletion in September, 1929, and an additional report is expected late in 1931. Embodied in the report to come will be the conclusions developed as the result of the public hearings on depletion in December, 1929, as well as much subsequent study given to this subject.

Valuation of Michigan Iron Mines

Michigan iron mines are valued at $90,894,000 for 1931, according to the recommendation of the state mine appraiser in his report to the State Tax Commission. This compares with a valuation for 1930 of $89,908,000. The reserves of iron ore on which these valuations are based are estimated at 170,987,345 tons, an increase of 2,637,522 tons over last year.

"The increase in reserves is largely due to the small shipments in 1930 and the resulting increase in stockpile ore," says the report. "Exploration, both surface and underground, is another factor that has been responsible for some of the increase in reserves.

"The overproductive capacity of the Lake Superior iron mines was evident in 1929 when the record shipment of that year was sent down the lakes with no great effort. The present large stock of ore at the mines, on the docks, and at the furnaces is a further demonstration of this same fact."

Tariff Commission Hears Feldspar Tariff Arguments

At a hearing before the U. S. Tariff Commission on September 17 on an application of the Consolidated Feldspar Corporation for a reduction in the duty of $1 per ton on crude feldspar and of 30 percent ad valorem on ground feldspar, domestic producers countered with an appeal for an increase in the duty. Under the law the Commission is restricted to a 50 percent increase or decrease in the tariff.

The position of the domestic industry was endorsed by the American Mining Congress in a brief by its secretary, J. F. Callbreath, and in testimony by A. W. Dickinson and H. M. Payne, of its staff. Mr. Dickinson read telegrams favoring an increased duty from Representative Williamson, of South Dakota, the Black Hills Mining and Industrial Association of Rapid City, S. Dak., and the Community Club of Keystone, S. Dak. The United Feldspar Corporation, through C. H. Peddrick, Jr., of New York, and the Feldspar Products Company, of Minnesota, also urged an increased duty.

Opposition to any duty on feldspar was expressed by V. V. Kelsey, of the Consolidated Corporation; Bruce Taylor, of the Genesee Feldspar Company, and H. H. Hanna, of the Seaboard Feldspar Corporation. The contention of the advocates of a higher duty on feldspar was that it was designed to meet the competition of Canadian feldspar, the American Mining Congress pointing out that it would permit the employment of 1,100 additional workmen in American mines at an annual wage of $140,000. When statement was made by Mr. Peddrick that the Consolidated Corporation had absorbed the duty during the last half of 1930 by not increasing the price of the Canadian product it handles, H. P. Margerum, of the Consolidated Corporation, admitted that his company had stocked its Rochester mill with a year's supply of Canadian feldspar in advance of the application of the duty under the tariff law of June, 1930.

The Gold Standard—
AN EXPLANATION

The function of the gold standard, in so far as the service it renders and the need there is for it, is set forth in the September bulletin of the National City Bank of New York.

"While the gold standard plays no more obvious part in the internal trade of other countries than it does in the internal trade of the United States," the bulletin states, "it links the monetary systems of all countries together and gives them a common basis for prices and financial operations. The currencies of all countries by having fixed relations to gold have fixed relations to each other and a given sum or price in the money of one country always means a certain sum or price in the currencies of all gold standard countries, subject to an exchange charge, which usually is less than the cost of shipping gold. This is the service of the gold standard to world trade and intercourse. Furthermore, it renders a stabilizing service to the internal trade of each country by attaching its monetary and price system to that of the rest of the world."

Gypsum Company Answers Trade Commission Complaint

The United States Gypsum Company has filed its answer to the complaint heretofore made against it by the Federal Trade Commission for advertising certain of its products as fire-proof and as being rock products. The answer sets out that gypsum is a hydrous calcium sulphate, which is incombustible and fireproof; that it is mined or quarried just as any other rock and that the manufactured products complained of in fact contain all the qualities of the original rock, and, like the rock from which they are made, are incombustible and fireproof. In the answer it is further shown that, since the inception of the gypsum industry, gypsum materials have been known as rock products and have been advertised as fireproof by the entire industry.

CENSUS OF MINES AND QUARRIES, 1929

Prepared under the direction of F. E. Berquist, Statistician for Mines and Quarries.

The Bureau of the Census announces the publication of detailed statistics, by states, for the copper-mining industry, compiled from data collected in the census taken in 1930 covering operations in 1929.

The copper-mining industry embraces those enterprises in which copper is the most important metal (based on net mine value) contained in the ore mined (or concentrates produced). Data for milling operations are excluded in the figures shown, but those for smelting and refining are included. Data for copper produced by those enterprises in which the principal values in the cre represent metals other than copper are included in the reports for the industries of the metals of greatest value.

TABLE I—Detailed General Statistics for the Copper Mining Industry, 1929.

	United States	Arizona	Montana	Utah	Michigan	Nevada	New Mexico	California	Colorado	Other States[1]
Number of enterprises[2]	143	63	7	9	9	13	14	10	3	15
Number of mines	180	68	26	10	18	13	14	11	4	16
Persons engaged in industry, total (all classes)	48,043	17,009	11,061	3,484	8,313	2,994	2,485	1,067	562	1,068
Proprietors and firm members	76	42	3	2	.....	8	9	4	.....	8
Principal salaried officers of corporations[3]	62	10	5	2	19	10	5	4	.....	7
Other salaried officers and employes[3]	3,403	1,393	545	320	460	278	213	65	49	80
Wage earners (average for the year)[4]	44,502	15,564	10,508	3,160	7,834	2,698	2,258	994	513	973
Principal expenses:										
Salaries and wages—										
Principal officers of corporations[3]	$382,961	$69,900	$24,483	$1,500	$148,278	$102,075	$1,550	$17,850	.....	$17,325
Other salaried officers and employes[3]	$9,753,393	$3,753,126	$2,327,790	$947,064	$1,081,823	$661,392	$526,869	$138,798	$116,420	$200,111
Wage earners	$13,215,540	$26,947,217	$18,747,609	$5,455,417	$9,838,442	$4,885,398	$3,409,479	$1,756,846	$774,844	$1,400,288
Contract work	$2,579,153	$1,129,548	(5)	$1,062,275	$32,962	$186,809	$18,274	.....	$97,274	$52,011
Supplies	$43,995,395	$16,919,123	$5,966,941	$8,088,202	$4,692,488	$3,634,556	$2,501,674	$1,106,824	$314,080	$781,507
Fuel	$9,210,052	$4,055,402	$346,410	$227,902	$2,397,922	$846,674	$1,186,534	$26,310	$37,112	$85,786
Purchased electric energy	$6,027,234	$1,488,400	$1,415,315	$2,323,293	$168,474	$112,154	$14,150	$237,032	$131,692	$136,724
Expenditures for development (included above in principal expenses)	$22,151,000	$9,087,000	$2,799,000	$3,430,000	$2,413,000 $29,683,859	$2,067,000 $19,984,910	$1,080,000 $13,293,420	$473,000 $4,748,996	$325,000 $1,697,051	$477,000 $3,746,136
Total value of products[6]	$283,517,373	$113,980,541	$50,154,473	$46,227,987	$713,520	$1,436,530	$844,976	$65,351	$6,537	$174,759
Machinery and other equipment purchased during the year, total cost	$13,083,523	$6,948,534	$503,281	$2,390,035	131,593	43,600	53,687	14,293	6,491	9,421
Prime movers and electric motors driven by purchased energy, aggregate horsepower	701,791	192,753	144,895	105,058	122,227	31,381	53,092	540	356	3,061
Prime movers, total horsepower	366,863	148,801	6,625	780	163	5	56	1	1	25
Steam engines	326	64	8	3	85,237	4,054	29,825	100	56	1,555
Horsepower	156,639	28,827	6,625	360	18	5	54	.....	.....	.....
Steam turbines	94	17	.....	.....	36,990	24,065	23,125	.....	.....	.....
Horsepower	189,123	104,943	.....	.....						
Internal combustion engines	142	100	.....	3	.....	12	5	4	2	16
Horsepower	19,726	15,031	.....	420	.....	2,762	142	40	300	1,031
Water wheels and water turbines	8	.....	.....	.....	.....	2	.....	1	.....	5
Horsepower	1,375	.....	.....	.....	.....	500	.....	400	.....	475
Electric motors driven by purchased energy	8,038	1,176	1,262	4,361	227	132	12	308	284	226
Horsepower	334,928	43,952	138,270	104,278	9,366	12,219	595	13,753	6,135	6,360
Electric motors driven by energy generated by enterprise reporting	4,726	2,740	.....	.....	908	428	648	.....	.....	2
Horsepower	270,205	165,164	.....	.....	52,795	23,364	28,867	.....	.....	15
Electric generators	108	58	1	.....	26	7	11	1	.....	4
Kilowatts	173,765	98,295	100	.....	28,560	24,975	21,045	400	.....	390
Fuel and electric energy consumed										
Fuel—										
Bituminous coal (tons, 2,000 pounds)	1,006,455	3,664	78,220	51,423	559,783	110,573	180,326	.....	5,325	17,141
Coke (tons, 2,000 pounds)	7,859	357	11	4,115	2,366	847	.....	.....	12	151
Fuel oils (gallons)	89,613,817	86,742,061	.....	246,632	170,945	487,145	1,419,154	403,155	83,375	61,350
Gasoline and kerosene (gallons)										
Electric energy—										
Generated by enterprises reporting (K.W. hours)	421,317	179,635	.....	57,060	75,743	15,510	36,635	27,044	1,557	28,133
Purchased (K.W. hours)	734,614,117	447,730,597	931,120	.....	132,274,897	70,281,100	82,640,653	685,750	.....	70,000
	758,119,336	129,638,797	259,332,810	294,844,338	11,341,254	8,487,210	560,243	28,509,537	8,196,400	17,208,747

[1]Idaho, 4 enterprises; N. C., 2; Oreg., 2; Tenn., 2; Vt., 1; Wash., 1; Wyo., 1.

[2]"Number of enterprises" represents number of returns received. In some cases a return covers an individual mine and in others a group of mines. A company operating in several counties was required to make a return for operations in each county separately. In some instances a separate return for each mine operated by a company within a single county was received. The number of enterprises is therefore somewhat greater than the number of operating companies.

[3]Not including data for number and salaries of officers and employes of central administrative offices.

[4]The average number of wage earners is calculated by totaling the numbers reported for the several months of the year (in most cases the number on the payroll on the 15th) and dividing the sum by 12. [5]Cost of contract work included in wages. [6]F. O. B. mine value of ore or concentrates.

TABLE II—Net Mine Value of Products of the Copper Mining Industry Showing the Values Contributed by the Metals Contained in the Ore or Concentrates[1]

	United States	Arizona	Montana	Utah	Michigan	Nevada	New Mexico	California	Colorado	Other States[2]
Total value of products	$283,517,373	$113,980,541	$50,154,473	$46,227,987	$29,683,859	$19,984,910	$13,293,420	$4,748,996	$1,697,051	$3,746,136
Value contributed by—										
Copper (in ore or concentrates)[3]	263,501,115	107,533,861	42,564,694	43,806,632	29,683,859	18,604,665	12,918,315	4,329,700	709,263	3,350,126
Lead (in ore or concentrates)[3]	1,371,846	20,345	674,181	234,743	.....	145,122	2,064	.....	295,391	.....
Zinc (in ore or concentrates)[3]	1,460,394	.....	1,385,035	37,711	.....	.....	1,879	.....	35,769	.....
Gold (in ore or concentrates)[3]	6,965,273	3,057,479	536,430	1,676,140	.....	1,024,712	294,422	268,557	62,645	44,888
Silver (in ore or concentrates)[3]	8,759,515	2,755,217	4,434,666	471,961	.....	210,411	76,740	150,168	593,983	66,369
Other products and service[4]	1,459,230	613,639	559,467	800	.....	.....	.....	571	.....	284,754

[1]The "value of products" for census purposes represents the value of the product as it leaves the mine, whether as ore or concentrates. The product is sold (or transferred to affiliated plants) as ore or concentrates, and the returns are based upon the recoverable content of the metals contained. Although the records of the separate values for each of the metals are not always kept, most operators were able to give accurate figures or good estimates of the net value at the mine of the metals contained in the ore or concentrates. The figures shown in this table represent the net mine value of the product showing the contribution to the total value of the different metals contained in the ore or concentrates.

[2]Idaho, 4 enterprises; N. C., 2; Ore., 2; Tenn., 2; Vt., 1; Wash., 1; Wyo., 1.

[3]The figures shown for the value of copper do not include the data for value of copper derived from gold, silver, lead, zinc or other mines.

[4]Manganese, pyrites, platinum, cadmium, lime, kaolin, misc. service.

Non-Ferrous Rate Structure and Railroad Plea for General Increase Absorb Attention of Interstate Commerce Commission

TWO important freight rate cases affecting the mining industry are before the Interstate Commerce Commission. One, which has been pending for two years, is the general investigation into the freight rate structure on nonferrous metals under the Hoch-Smith act of Congress to readjust the freight rate structure, and the second is the application of railroads, made in June, for a general freight rate increase of 15 percent.

The nonferrous metal rate case is slated for final hearing before the Commission at Chicago on October 15. Thereafter the examiner will prepare his recommendations and the final step preparatory to a decision in the case will be argument of the case before the Commission in Washington. The argument of the case and its decision is not expected until some time in 1932. In the hearings in this case the shippers have been a unit in opposing any disturbance of the present freight rate structure on nonferrous metals because of the depressed conditions in the industry and the further fact that existing rates are fairly compensatory to railroads and all that the traffic can bear. The railroads have not proposed any changes in these rates to date, but are expected to outline their recommendations at the Chicago hearing.

Practically all branches of the mining industry have been a unit in opposing the 15 percent freight rate increase. The Utah Chapter of the American Mining Congress, the American Zinc Institute, the Anthracite Coal Operators Association, the Lake Superior Iron Ore Association, and numerous other mining organizations have offered testimony in opposition to advanced freight rates. Final arguments on this case were heard by the Commission at Washington beginning September 21 and a decision is expected early in October. The main points of the opposition to the rate increase have been that the present depressed conditions in all lines of industry will not be improved by added freight charges, that shipments will be diverted to trucks, water routes, pipelines, and other forms of transportation, and that the railroads are no worse off than other industries.

A. G. Mackenzie Outlines Position of Western Mining Industry

Based on his familiarity with mining conditions in Utah and other western states for more than 30 years, A. G. Mackenzie, secretary of the Utah Chapter of the American Mining Congress, presented a mass of statistical and other economic data and arguments at the Salt Lake City hearing in opposition to the rate advance. Included in this data was a summary of evidence taken previously by the Commission in its investigation of the rate structure on nonferrous metals, information as to the economic dependence of the people of Utah on its mining industry and a statement on the status of the nonferrous metal mining industry in Utah and other western states on July 1 of this year as compared with normal operations.

"The combined business of mining and smelting has been the backbone of the industrial development and the increase in population of several of these western states, including Montana, Idaho, Colorado, Arizona, New Mexico, and Utah," said Mr. Mackenzie. "The mines are not owned by a few persons, but by many in all walks of life. The industry furnishes a very large proportion of the railroad freight tonnage in supplies as well as in the mine products. It furnishes the largest home markets for the products of agriculture. The percentage of the population of Utah dependent upon metal mining is 47.17 percent. The nonferrous metal industry pay roll constitutes 20 percent of the total pay roll of all industries in the state. The mineral industry, of which nonferrous metals constitute the greatest part, consumes one-third of the agricultural products marketed in the state. Ore, concentrates and bullion constitute 60 percent of the railroad car loadings of the state.

"The metal mines are heavy taxpayers in Utah," continued Mr. Mackenzie. "Metal mining property is fully assessed, and is a very important source of state and local revenue, the principal source in several counties and practically the only source in many communities. Limitations fixed by nature make it impossible for more than 5 percent of the area of Utah to be intensely cultivated, and continued and greater utilization of its mineral resources is a natural line, provided the mineral industry receives the protection and support necessary to make that development feasible. Bullion, because of its favorable transportation characteristics, is most desirable traffic from a railroad standpoint. The industry is contending that the existing rates on its commodities are sufficient; that the bullion traffic is profitable for the railroads and yields them an adequate return for the service rendered; and that the metal industry is bearing its full and fair share of the transportation burden. Pending decision in the general investigation of the rates on nonferrous metals, those rates should not be disturbed.

"The mining industry is not using the depression as a reason for charity in the matter of railroad freight rates, but it is asking a full measure of justice in the premises to the end that there may not be cast upon the industry a burden beyond its power to absorb. The industry is less able to sustain any additional burden at this time than at any time within our experience here. The traffic can not bear higher freight rates and any increase would stifle the movement of ores and metals and make a bad situation worse. The vital need is to promote a return of a normal flow of traffic. The free movement of nonferrous metals is an auxiliary to the production of a tremendous volume of subsidiary tonnage to the railroads. The proposed freight rate increase would result in a pronounced further curtailment and possibly in complete suspension of nonferrous metal mining and smelting activities in Utah and other western states, making it certain that the economic recovery of the industry and business in those states would be prolonged far beyond the period through which it would otherwise exist."

Mr. Mackenzie's testimony was given in cooperation with Russell Lucas, counsel and rate specialist for the Utah Copper Company.

The Lake Superior Iron Ore Association declared that present iron ore freight rates are exorbitantly high, based either on the cost of the service rendered by railroads or on net railway operating income of roads whose traffic consists wholly of iron ore. Iron ore should be exempted from a rate increase if any is granted, the association stated. It was claimed that the present iron ore rates are highly compensatory and that railroads engaged wholly in transporting iron ore are among the most prosperous, based on trackage and equipment.

The final presentation of evidence in the railroads' application for increased revenues began August 31 before the Interstate Commerce Commission in two concurrent hearings held in Chicago. Dr. Julius H. Parmelee, director, Bureau of Railway Economics, the first railroad witness, submitted exhibits covering railway revenues and expenses for the first half of the current year.

The sharp decline in revenues which is seriously menacing the railways' ability to provide adequate service has shown no definite change in trend, according to Dr. Parmelee's figures. Total operating revenues of the Class I carriers declined 18.7 percent during the first six months of 1931, as compared with the corresponding period a year ago. Total operating expenses declined 17.2 percent and total maintenance was reduced 20.9 percent. Transportation expenses showed a drop of 15.6 percent and net railway operating income fell 36.8 percent.

Personals——

JAMES O. ELTON, general manager of the International Smelting Company, delivered the address of welcome to the annual meeting of the Electrochemical Society of America, meeting in Salt Lake City early in September.

✣

ROBERT E. TALLY, vice president of the United Verde Copper Company, addressed the cattlemen of Yavapai County at Prescott, Ariz., the latter part of August, on "The Present Industrial and Financial Situation."

✣

E. B. WEIR, formerly of the Consolidated Mining & Smelting Company, has accepted a position with the engineering department of the International Nickel Company.

✣

HARRY A. CLARK, general manager of the Calumet & Arizona Mining Company, has been appointed a member of the Arizona Fish and Game Commission.

✣

J. P. HODGSON, manager of the Copper Queen Branch of the Phelps Dodge Corporation, left the latter part of August on a trip which will include Los Angeles, the Panama Canal, New York, Niagara Falls, the Sudbury nickel district, and Marquette, Mich.

✣

L. S. CATES, president of the Phelps Dodge Corporation, returned from Europe the latter part of August.

✣

THOMAS K. SCOTT, of the operating staff of the M. A. Hanna Company, Iron River, Mich., was recently made superintendent of the Bates iron mine, on the Menominee Range.

✣

JOHN C. NICHOLLS, of Copper Cliff, Ontario, left recently for Great Britain for an inspection of the International Nickel Company's overseas operation.

✣

J. F. CALLBREATH, secretary, and A. W. DICKINSON, chief of the Tax Division of the American Mining Congress, were in Joplin, Mo., the latter part of September to attend the joint meeting of the Western Division of the Mining Congress and the A. I. M. E. Mr. Callbreath addressed the convention on "Problems Facing Mineral Producers," and Mr. Dickinson discussed "National Revenue and Mining."

✣

W. MONT FERRY, vice president and managing director of the Silver King Coalition Mines Company and president of the American Silver Producers Association, addressed the annual meeting of the Western Division at Joplin, September 29, on "The World Silver Problem."

✣

DEAN FRANK H. PROBERT, of the Department of Mines of the University of California, spoke at the same session on "Stabilizing Our National Resource Industries."

✣

WALTER G. SWART, vice president of the Mesabi Iron Company, Babbitt, Minn., recently returned from the East.

✣

ERSKINE RAMSAY, chairman of the board of the Alabama By-Products Corporation, and prominent in the coal industry of the South, celebrated his sixty-seventh birthday anniversary on September 24 at his home in Birmingham with a huge party, which was attended by many of his friends from far and near. Part of the program arranged for the event, including remarks by several of the guests and Mr. Ramsay, and selections by a Scotch chorus and orchestra, was broadcast over Station WAPI.

✣

JOHN L. DYNAN, formerly mining engineer for the Tonopah Extension Mining Company and later in charge of the Wickenburg, Ariz., property of the Tonopah Belmont Mining Company, has been appointed as principal of the Tonopah School of Mines, at Tonopah, Nev.

Mr. Dynan succeeds J. P. Hart, who has resigned to join the Treadwell-Yukon Company as engineer of their mines at Tybo, Nev.

✣

ROBERT D. BRADFORD, assistant to the vice president of the American Smelting & Refining Company, New York City, was a visitor in Salt Lake City the latter part of August and early in September.

✣

W. C. MENDENHALL, director of the U. S. Geological Survey, and R. M. WOOLLEY, hydraulic engineer of the Geological Survey, were in Salt Lake City early in September and called upon Governor George H. Dern.

✣

H. FOSTER BAIN, since 1925 secretary of the American Institute of Mining and Metallurgical Engineers, will relinquish that post November 1 to accept a position with the Copper & Brass Research Association. Prior to assuming the position of secretary of the institute, Mr. Bain served as director of the United States Bureau of Mines, having been appointed in 1921. He is widely known to those in the mining industry the world around. He was editor of Mining & Scientific Press from 1909 to 1914, and of the Mining Magazine in London during 1915 and 1916. From 1916 to 1920 he was engaged in foreign exploration in South Africa and the Far East, except for one year during the war, when he served as assistant director of the Bureau of Mines in charge of the production of war minerals.

✣

GEORGE JAY, purchasing agent for the Calumet & Arizona Mining Company, recently returned to Bisbee, Ariz., after a vacation on the Pacific coast.

✣

AMOR F. KEENE, consulting mining engineer, New York City, recently completed a three weeks examination of the Nevada Porphyry Gold Mines property at Round Mountain, Nev., where a mill is being planned.

✣

WILLIAM R. WADE, manager of the Engineers Exploration Syndicate, New York City, and J. J. BEESON, manager of the Park City Consolidated Mines Company, Salt Lake City, have recently returned from a trip through Idaho, Nevada, and California.

✣

JOHN G. MILLHOUSE, director of the Illinois Department of Mines and Minerals, Springfield, is chairman of the arrangements committee for the annual fall meeting of the Illinois Mining Institute, which will be held at Springfield, Friday, November 6.

✣

L. T. DEE, president of the Ideal Coal Company, Ogden, Utah, has been elected a director of the National Coal Association to serve the unexpired term of the late P. J. QUEALY. MR. DEE was reelected president of the Southern Wyoming Coal Operators' Association at its recent meeting in Rock Springs.

✣

H. A. GLOVER, general sales manager, Consolidation Coal Company, has been reelected as chairman of the Committee of Ten—Coal and Heating Equipment Industries.

JOHN G. BARRY, consulting mining geologist and engineer of El Paso, Tex., has been appointed president of the Texas College of Mines and Metallurgy at El Paso by the Board of Regents of the University of Texas. This gives this institution a president of its own for the first time.

While Mr. Barry has been actively engaged as a consulting mining geologist and engineer since leaving his position as chief geologist with the American Smelting and Refining Company in 1924, he previously taught, first in the Geology Department of the University of North Dakota, 1907-09, and later at the Massachusetts Institute of Technology, 1916-20, of which institute he is a graduate in the class of 1907. His work at the Massachusetts Institute of Technology was interrupted during the World War by service overseas as lieutenant-colonel in the Chemical Warfare Service.

Mr. Barry has assumed already the duties of president of the college, but will continue his consulting practice on a limited scale.

✣

JOSEPH J. WALSH, Wilkes-Barre, Pa., has been appointed deputy secretary of mines of Pennsylvania, to fill the vacancy created by the death last fall of JOHN R. JAMES. MR. WALSH was head of the State Department of Mines during the first Pinchot administration.

✣

DR. A. W. GAUGER, former director of the Division of Mines and Mining Experiment at the University of North Dakota, has been appointed director of the Mineral Industries Experiment Station and professor of fuel technology at Pennsylvania State College.

✣

PENROSE HERTZLER, of Port Royal, Pa., has been appointed by A. J. MALONEY, president of the Philadelphia & Reading Coal & Iron Company, as counsel for the company to deal particularly with compensation cases. Mr. Hertzler was formerly a special deputy attorney general with the Pennsylvania Department of Justice. His headquarters will be at Pottsville.

✣

CHARLES O'NEILL, vice president of Peale, Peacock & Kerr, Inc., New York City, has been chosen to represent the National Coal Association at the National Conference on the Relation of Law and Business, With Specific Emphasis on Anti-Trust Laws, which will convene in New York on October 26.

✣

FRANK M. SMITH, Spokane, Wash., smelter director of the Bunker Hill Mining & Concentrating Company, is on an extended trip to Montreal, Toronto, New York and Washington.

STABILIZATION

PLAN OF THE AMERICAN BAR ASSOCIATION

The American Bar Association proposes amendment of the anti-trust laws to confer upon the Federal Trade Commission the power to pass in advance on restraint of trade contracts voluntarily submitted, and to grant immunity to parties to contracts approved by the commission from the provisions of the anti-trust laws.

It is pointed out that during the past five years more than 125 American industries have held trade practice conferences under the auspices of and in cooperation with the commission. The conferences have afforded an opportunity for an industry to apply the statutory standards of unfair competition to the particular facts of that industry, and to secure an advance expression from a responsible branch of government as to its opinion of the legality of proposals for the elimination of unfair competition. It was said that American business has welcomed this opportunity and that the conferences have filled a real need. But in developing the conferences the commission has proceeded without any specific statutory authority. This fact has exposed the commission to criticism for its initiative which would not otherwise have arisen. One of the values of the conferences has been the opportunity afforded for experimentation in the application of statutory generalizations to the practical economic facts of particular industries and situations. The question has also been raised as to whether the entire movement might not be abandoned or substantially modified from the purposes originally announced. Within recent months the commission has made some effort to clarify the situation and has definitely indicated that it has no intention of abandoning the trade practice conference movement. The Attorney General has also expressed general approval.

The Bar Association says the uncertainty in which the conferences still find themselves indicates the desirability of a clearer statutory definition of the commission's authority and power with respect to the conferences and the regularization of their procedure, including provision for the harmonization of the functions of the commission with those of the Department of Justice and the courts in dealing with conference rules. The Association recommends specific statutory authorization of the commission to pass in advance on the application of the anti-trust laws to particular agreements.

MR. GERALD SHERMAN, formerly consulting mining engineer for the Phelps Dodge Corporation at Douglas, Ariz., is now engaged in some special work for the Philadelphia & Reading Coal & Iron Company, with headquarters at Ashland, Pa.

✣

E. L. GREEVER, attorney of Tazewell, Va., has been appointed to membership in the Council of the Mineral Law Section of the American Bar Association. Mr. Greever for the past year represented the National Coal Association on the Committee of Nine of the Mineral Law Section, which committee was appointed to study the advisability of proposed mineral legislation.

Obituary

GEORGE CLEGHORN MACKENZIE, 54 years old, secretary-treasurer of the Canadian Institute of Mining and Metallurgy for the past 10 years, died suddenly on August 22 while vacationing at Bark Lake, Quebec. Death was due to heart failure.

Following his graduation from Kingston School of Mines in 1903, Mr. Mackenzie went with the Londonderry Iron & Mining Company, Nova Scotia, as assistant blast-furnace superintendent. He served with the Ontario Bureau of Mines in 1907 and then joined the staff of the Department of Mines at Ottawa, with whom he remained until 1915, when he was appointed secretary to the Munitions Resources Commission of Canada. After the war (1919) Mr. Mackenzie accepted the position of general manager of the Electro Steel & Engineering Company, of Welland, Ontario. Shortly after this he was selected by the Council of the Canadian Institute of Mining and Metallurgy to fill the post of secretary-treasurer of that organization, assuming his duties on January 1, 1921.

FRANK CORWIN, vice president of the Nichols Copper Company, died in New York on September 15, following a heart attack. He was about 40 years old.

DR. HARRY PHILLIPS DAVIS, vice president and director of the Westinghouse Electric and Manufacturing Company and chairman of the National Broadcasting Company, one of the country's foremost engineers and executives, died at his home, Pittsburgh, Pa., on September 10. He had been ill for several months following an operation.

For more than 21 of the 40 years during which he was connected with the Westinghouse Company, Dr. Davis was in charge of his company's engineering department, and for 15 years directed its engineering and manufacturing operations.

Board Considers Muscle Shoals

Consideration is being given by a Federal and state board of proposals to lease the Muscle Shoals, Ala., nitrate and power project. This board consists of representatives of the Government appointed by the President and of the states of Alabama and Tennessee by appointment of their state governors, and was organized following the suggestion of the President that such an organization consider the question which has been the subject of indeterminate consideration by Congress during the past 10 years. Congress has twice passed legislation for Government operation of these projects, but it has been vetoed by Presidents Coolidge and Hoover. The joint Government and state board recently received several offers from companies and individuals for the lease of this project and is expected to receive additional proposals early in November. The board will in turn report to their state governors and to the President who will transmit the matter to Congress for consideration at the next session of Congress.

Urge Oil Proration Conference

In conferences with the President, Secretary of Commerce Lamont, and Chairman Fletcher of the Tariff Commission, representatives of oil producers in Kansas, Oklahoma, and Texas urged the calling of an international conference to pro rate oil production during the next three years in order to prevent overproduction and to increase the price of oil. Pending further consideration of the matter by Government officials, it was said that the American Petroleum Institute might call a conference. The purpose is to regulate production in the following zones: United States and Canada, Russia, South America and Mexico, Europe and the Orient. The oil men plan to submit the proposal to the State Department within a month, and said the extent to which oil imports are curtailed will determine whether the industry will seek a tariff on oil from Congress, which when it meets will be furnished by the Tariff Commission with a report on domestic and foreign oil production costs.

The United States center of population is 2.9 miles northeast of Linton, Ind. The Census Bureau states that it moved 22.3 miles west and 7.6 south during the 10 years between 1920 and 1930.

The total westward movement of the population center from 1790 to 1930 was 589 miles. It was located at the time of the first census 23 miles east of Baltimore, Md.

STABILIZATION

PLAN OF GERARD SWOPE

President, The General Electric Co.

"To stabilize production, consumption and employment, there should be established in each industry a trade association to be under supervision of the Federal Trade Commission, the Department of Commerce or some other federal agency. These associations would control production, outline trade practices, business ethics and methods of standard accounting and cost service, and collect and distribute information on the volume of business, inventories, standardization of products, stabilization of prices and other matters relating to the development of industry and commerce in order to promote stabilization of employment. The plan would embrace industrial and commercial companies having 50 or more employes doing an interstate business. The new industrial policies would apply to an entire industry and not to any of its single units in order to promote the security of workers if transferred from one company to another in that industry. Companies participating in the plan would provide workmen's compensation, life, disability and unemployment insurance, and pensions. Each trade association would have a board of nine members representing the companies, employes and the public, to supervise the individual boards of administration in the various companies.

"It is claimed that this plan would put all domestic corporations of a given class on a parity for domestic business, remove the inequalities of different State laws, provide for standard forms of financial reports, place on organized industry the obligation of coordinating production and consumption, and secure a higher degree of stabilization. To put the plan in operation, there will be the necessity of modifying existing laws."

Germany Leads In Export To Soviet

Germany replaced the United States as Soviet Russia's principal buying market in the first six months of 1931, as compared with the same period in 1930, according to the Chamber of Commerce for Western Trade, Moscow.

Soviet imports from Germany during the period were 162,718,000 rubles compared with 142,652,000 from the United States. This is compared with 105,503,000 rubles spent in Germany during the first six months of 1930 and 167,056,000 spent in the United States.

A. I. M. E. Coal Division To Meet At Bluefield, W. Va.

The Coal Division of the American Institute of Mining and Metallurgical Engineers will hold its fall meeting in the Pocahontas field, at Bluefield, W. Va., October 9 and 10. The first day will include two sessions for the presentation of papers and a dinner in the evening. The second day the members will be the guests of the operators on a trip through the Pocahontas field.

Hon. E. Fudge, assistant undersecretary, Mines Department, and R. V. Wheeler, head of the Mines Research Board of Great Britain, will be guests. Mr. Wheeler will discuss the British Mining Act as relates to the coal industry. George S. Rice, chief mining engineer, U. S. Bureau of Mines, will present an account of the recent meeting at Buxton, England, of representatives of England, Germany, France, Belgium, and the United States, to formulate a plan and to correlate research work now in progress in the various countries. Authors of other papers to be presented are; Howard N. Eavenson, T. W. Guy, R. F. Roth, R. N. Hosler, A. C. Fieldner, W. A. Selvig, and F. H. Gibson.

Coal Utilization Research

The legislature of the State of Utah has made an appropriation of $10,000 to the University of Utah for the next two years, to be expended in coal utilization research. The money is made available on condition that a similar amount is provided from other sources.

Reports Show Coal and Metal Mine Production by States

Statistics for the various coal-producing states have been issued by the Bureau of Mines giving the following figures for 1930, by counties: Tons of coal loaded at mines for shipment, sold to local trade, used at mines, made into coke at mines; average and total value per ton; number of employes according to class of work; average number of working days; and average tons per man per day. Reports are available for Alabama, Arkansas, Colorado, Indiana, Iowa, Kansas, Maryland, Missouri, Montana, New Mexico, Ohio, Oklahoma, Tennessee, Utah and Wyoming. *Copies may be obtained from The Mining Congress Journal.*

The mine production of gold, silver, copper, lead and zinc, by quantity, number of producers, ore treated and total value for the year 1930 is shown in another series of reports issued by the Bureau covering each of the western metal mining states. The statistics are given by counties. *The Mining Congress Journal will furnish copies upon request.*

Anthracite Rates Reduced

Freight rates on anthracite in carloads from three producing fields of Pennsylvania to points in South Jersey were reduced the latter part of August by the Interstate Commerce Commission. Commissioner Eastman stated that he believed still lower rates should have been prescribed from Reading mines in the Schuylkill region, inasmuch as these mines furnish the nearest sources of anthracite and are therefore entitled to the full benefit of their location in that respect.

Lake Erie Coal Shipments

Lake Erie bituminous coal dumpings during the season to September 1, 1931, totaled 18,729,902 tons, against 24,945,595 tons in the corresponding 1930 period, 27,760,389 tons in 1929, and 20,823,983 tons in 1928, according to the Ore & Coal Exchange.

Coal Production in August

The total production of bituminous coal for the country as a whole during the month of August is estimated by the Bureau of Mines at 30,534,000 net tons. Compared with the output in July, this shows an increase of 744,000 tons, or 2.5 percent. The number of working days in the two months was the same—26 days. Production in the month of August, 1930, amounted to 35,661,000 tons.

STABILIZATION

PLAN OF AMERICAN FEDERATION OF LABOR

By William Green, President

National sustained prosperity depends upon the payment of high wages.

The five-day week will benefit not only the workers, but the business interests.

Advanced planning by the government for public works to be constructed during depressions will be of immeasurable benefit.

There can be no prosperity unless the workers receive more than a subsistence wage. Prosperity depends upon the purchasing power of the people.

Where an employer fixes the wage scales and working conditions without consultation with his employes, the latter soon become victims of greed, force and selfishness.

Some of the heads of the greatest corporations in America have publicly stated that if business is to revive there must be no cutting of wages.

Shipments of anthracite for the month of August, 1931, as reported to the Anthracite Bureau of Information, Philadelphia, amounted to 3,401,981 gross tons. This is an increase, as compared with the preceding month of July, of 313,311 tons, and when compared with August, 1930, shows a decrease of 1,419,809 tons.

Illinois Mining Institute To Meet November 6

The annual fall meeting of the Illinois Mining Institute will be held in Springfield, Ill., on Friday, November 6, with headquarters at the Abraham Lincoln Hotel. The morning session will open at 10 o'clock with a business meeting, followed immediately by the technical papers, which will be presented and discussed both morning and afternoon. There will be a dinner in the evening.

The program committee has been at work for some time, and an interesting and instructive program is assured. B. E. Schonthal, 224 South Michigan Avenue, Chicago, is secretary-treasurer of the Institute.

Bituminous Coal Map of Pennsylvania is Published

A new map showing in colors the mine inspection districts of the bituminous coal fields of Pennsylvania has been issued by the Department of Mines of Pennsylvania. It gives the location of each mine with an index showing the mines in each inspection district, classification of mines as to annual production and the name of the company or operator. A table is included showing production, employes and fatalities from 1877 to 1930. The last similar map was issued about 10 years ago and since that time many mines have been exhausted, others abandoned and some new mines opened.

Fascinated by the uniform

Louisville Courier-Journal

N. Y. Herald-Tribune

MINE ACCIDENT PREVENTION

To Be Discussed at Safety Council Meeting

DURING the week of October 12 to 16, many delegates from mining, cement and quarry industries of the United States will meet at the Stevens Hotel in Chicago to carry out conference programs to consider practical ways and means for the reduction of accidents and accident costs in these industries.

Frank B. Dunbar

These accident prevention programs, as an important part of the Twentieth Annual Safety Congress and Exposition, will be conducted by three different cooperative groups of the National Safety Council—namely, the Mining Section, the Cement Section and the Quarry Section.

The Mining Section will have five program sessions on Tuesday, Wednesday and Thursday of Congress week. The general chairman will be Rush N. Hosler, of the Coal Mine Section of Pennsylvania Compensation Rating and Inspection Bureau. Features of the first Tuesday morning sessions will be an address on "Relation Between Illness and Safety in Mining," by Dr. R. R. Sayres, United States Bureau of Mines, and "Discipline in Relation to Accidents," by Frank B. Dunbar, general manager, Mather Collieries Co.

The Tuesday afternoon session will feature addresses on "Educative Processes in Accident Prevention Work," by Wm. Conibear, assistant superintendent, The Cleveland-Cliffs Iron Co., and "The Safety Plant of the National Coal Association," by Milton H. Fies, chairman of the safety committee of the National Coal Association.

William Conibear

For the Wednesday afternoon session there will be an address on "Inspection of Electric Equipment in the Mining Industry," by Prof. A. C. Callen, of University of Illinois. L. Fern Pett, safety engineer of Utah Copper Company, will discuss "Mechanical Safety in Mining and Milling." There will be a question box discussion of the important question "What Are the Advantages and Disadvantages of Physical Examinations Before Employment and at Six or Twelve Month Intervals During Employment?"

The Thursday morning session will include an address on "Preventing Accidents from Roof Falls," by W. B. Hillhouse, Alabama chief mine inspector, and Question Box discussion on "What Is the Best and Safest Method of Illumination in Coal Mines —and in Metal Mines?"

Milton A. Fies

Organizing Safety Institutes

A mining safety institute in the Williamson, West Virginia, field is being organized under the direction of John C. Kennedy, safety engineer of the National Coal Association, who recently presented plans and methods for the organization to the executive committee of the Operators' Association of Williamson Field. An organization meeting of chief executives and mine superintendents of 18 operations was held and a committee appointed to draft by-laws for the Institute. These will be presented at the next meeting.

Similar institutes have been formed in Virginia and Kentucky. At a meeting of the safety committee of the Virginia Coal Operators' Association the latter part of July, the committee recommended the formation of one central safety institute, with monthly meetings to be held at Norton.

Thirty-two representatives of producing companies in the locality of Jenkins, Ky., recently voted to set up a safety institute, and the name of Elkhorn Coal Safety and Mining Institute was tentatively adopted. Following a suggestion of John F. Daniel, chief of the Kentucky Department of Mines, it is likely that the Jenkins operators will affiliate with the Hazard Safety Institute in the hope of enlarging and strengthening the organization.

An organization known as the Big Sandy Mining Institute has also been formed at Prestonburg, Ky.

Consol Teams Win Maryland First Aid Meet

Before a record crowd, the Consolidation Coal Company won all prizes in the Fourth Annual Maryland State First Aid Meet at Frostburg, August 22, in which 26 teams took part, representing 12 companies. The meet, under the direction of Dr. J. J. Rutledge, chief, Maryland Bureau of Mines, was one of the final events on the program of the State American Legion convention.

First prize in the first-aid contest, consisting of the Ritchie cup and $120 in cash, was won by Consolidation Mine No. 1, Team No. 3, which had a rating of 99.90 percent. The team winning second prize, an award of $60 in cash, represented Consolidation Mine No. 10, Team No. 3, rating 99.80 percent. Third prize, $30 in cash, was awarded Consolidation Mine No. 12, Team No. 1, with a rating of 99.75 percent.

A feature of the contest was the fact that 11 teams made an average of 99 percent or better, and of the 26 teams participating, the lowest average was 96.10 percent.

The contest was under the direction of George Riggs, Mine Safety Appliances Company, assisted by George S. McCaa, of the Pennsylvania Department of Mines.

A survey made by the Census Bureau last year and just made public reveals that out of a total of 59,639 coal-mine workers in Illinois, 9,449 were unemployed; and of 7,271 in other mineral industries, 459 were idle. In addition, 11,377 coal miners and 211 engaged in the extractive mineral industries were laid off.

1931 Coal Mine Fatality Rate Lowest in History

Reports made to the Bureau of Mines show that during the first eight months of 1931, 960 lives were lost in the mining of 289,931,000 tons of coal. The fatality rate, 3.31 per million tons for the period January to August, 1931, sets a new mile-stone for safety in mines in the United States as far as the human-life cost of coal is concerned. The rate of 3.31 represents an improvement of 13 percent as compared with the rate of 3.82 for the corresponding months of 1930, and it indicates a better situation than has obtained in the coal industry any past year.

The death rate for bituminous mines alone decreased from 3.41 for the first eight months of 1930 to 2.79 for the same period in 1931. There were 1,025 deaths during the eight-month period of 1930 and 699 during the same months in 1931. The decrease in the fatality rate for bituminous mines amounted to 18 percent in favor of the current year. The record for anthracite mines was not so marked, the fatalities declining from 297 in the eight-month period of 1930 to 261 for the same period of 1931, and the death rate remaining practically unchanged, being 6.55 for 1930 and 6.56 for 1931.

Accidents at coal mines during August caused the death of 112 men. This was one more than the number of deaths reported in July, 1931, but it was 51 less than the number of men killed in August, 1930. Production of coal amounted to 34,848,000 tons in August of the present year, an increase of 3.27 percent over the 33,744,000 tons mined in July, but a reduction of 16.66 percent from the output of 41,814,000 tons in August a year ago. The death rate per million tons, based on these figures were 3.21 for the present month, as compared with 3.29 for July, 1931, and 3.90 for August, 1930. There were no major disasters in August.

Considering bituminous mines alone, the fatality rate of 2.78 for August of the present year was lower than that for the preceding month of July, with a rate of 3.02, and that of August a year ago, when a rate of 3.28 was shown. Eighty-five men were killed in bituminous mines in August, 1931, as compared with 90 in July, 1931, and 117 in August, 1930.

In the anthracite mines of Pennsylvania 27 men were killed in August, 1931, as compared with 21 in July of the present year, and 46 in August, 1930. The fatality rates for these months were 6.26, 5.31, and 7.48, respectively.

ILLINOIS FATALITY RATE LOWER

Based on tons mined to one fatality, the fatality rate for the mines of the State of Illinois is lower for the first eight months of 1931, than for the similar period of the previous year, according to the Department of Mines and Minerals of the State of Illinois.

In August, 1931, these mines produced 3,299,871 tons of coal, with 8 fatalities, and 563 injured (loss of one day or more). In August, 1931, there were 34,347 men employed by 116 mines. Based on a production of 27,792,719 tons and 50 fatalities during the first eight months of 1931, there were 555,814 tons mined per fatality during that period. Like figures for the January to August period of 1930 were 32,443,282 tons mined and 456,948 tons mined per fatality.

Good Safety Records at Cleveland-Cliffs Mines

On September 2, the Hill-Trumble Mine of The Cleveland-Cliffs Iron Company at Marble, Minn., reached the goal of one year's operation without sustaining a lost-time accident.

Other Cleveland-Cliffs properties have made some enviable safety records. Up to September 1, the Tilden mine had operated 620 continuous days without a lost-time accident; the Holman-Cliffs mine, 520 days; Gardner-Mackinaw mine, 469 days; Spies-Virgil mine, 217 days; Morris-Lloyd mine, 216 days; Canisteo-Cliffs mine, 167 days; Cliffs-Shaft "B," 107 days; Negaunee mine, 79 days; Cliffs-Shaft "A," 54 days.

Three accidents during August, one at each of three mines and the only ones in the entire organization, ended records of 238, 202, and 111 days at the Alexandria, Maas, and Athens mines, respectively.

Southern Appalachian Operators Conduct No-Accident Campaign

During the month of August, Southern Appalachian Coal Operators' Association conducted a no-accident campaign in the Knoxville, Tenn., field. Flags were sent to each mine and were raised on the last day of July, these flags to remain flying until there was an accident.

On the 1st day of September, out of 36 mines, 21 flags were still flying. To these 21 mines which had no accidents during the month of August a large permanent flag was given, showing they had a perfect record during August. There were only 20 slight injuries for over 10,000 men working 30 days.

This campaign was conducted and managed by a safety committee composed of Mr. J. E. Butler, general manager of Stearns Coal & Lumber Co., chairman; Mr. J. B. Gatliff, president of Gatliff Coal Company; and Mr. C. A. Griffith, vice president and general manager of Pruden Coal & Coke Co.

A Suggestion for Using Molten Lead Underground

A suggestion for users of molten lead and its alloys is given in the September bulletin of the Lead Industries Association as follows: "At the Dominion Coal Company mine at Spring Hill, Nova Scotia, molten lead had to be used a mile from the mouth of the mine. No fire could be used underground. J. H. Mann, master mechanic, had a box constructed 14 in. square and lined with blocks of J-M 85 percent magnesia 2 in. thick. The lead was melted in the shop and the container of molten lead placed in the box for transport underground. This lead was still fluid three hours later."

U. M. W. Again To Seek Coal Legislation

Following the failure of a national conference of the bituminous industry for consideration of plans to stabilize operating and other conditions, John L. Lewis, president of the miners' union, announces that efforts will be made to have the next session of Congress pass legislation to regulate the industry. The union will again urge action on the bill sponsored by it in 1928 and introduced by Senator Watson (Rep., Ind.), for supervision of the industry by a commission which would license consolidations and cooperative marketing agencies, prescribe maximum prices, promote the export trade and prevent discrimination between mines or fields in the purchase of railroad fuel.

WITH THE MANUFACTURERS

Vulcan "Duplex" Steam Locomotive

The Vulcan Iron Works, of Wilkes-Barre, Pa., have met a special need in the field of its activities with the introduction of a new type of locomotive, the first of its kind built in America. This Vulcan "Duplex" locomotive was only recently completed and is now in actual service at coal mine strippings in the Hazleton region, for the Lehigh Valley Coal Company.

The locomotive has a flexible wheel base, capable of handling very heavy loads. There is a guarantee of much greater hauling capacity than the ordinary steam locomotive.

This new design meets the demand for a comparatively heavy steam locomotive distributing the weight over a greater length of rail and a greater number of ties, making it easier on track upkeep, and especially adaptable to all conditions involving the handling of heavy loads on steep grades with sharp and kinky curves. It has an advantage over the simple rod locomotive of rigid frame wheel base in having two swiveling trucks, enabling it to negotiate sharper curves and provide for greater traction on poorly constructed road beds.

The locomotive illustrated weighs 55 tons in full service order, with the weight properly distributed over eight driving wheels. The 8-wheel arrangement consists of two four-wheel swiveling trucks, each having a pair of 13-in. by 16-in. piston valve type cylinders. Each truck is a complete unit in itself and obtains its steam through flexible connections from the boiler. Driving wheels are 33-in. diameter; truck wheel base 5 ft.; and total wheel base is 26 ft. 5 in. The length of the locomotive over bumpers measures 32 ft. 6 in.

The main locomotive frame, which carries the boiler, cab, tank and upper structure, is of heavy structural steel design. The boiler is of extended wagon top type with charcoal iron tubes. The water tank, located over the rear engine truck, holds 1,400 gallons and is equipped with a feed water heater. Space is provided for approximately 5,000 lbs. of coal. The locomotive is equipped with Westinghouse modified airbrake apparatus.

A notable feature of the locomotive is the steam control. By means of a special arrangement in the steam line, both trucks may be operated simultaneously or the steam to either truck may be partly or completely shut off to prevent slipping of wheels. This operates entirely independent of and does not interfere with the main throttle.

It is the intention of the builders to further develop this design into a range of sizes or weights to meet practically all industrial haulage requirements.

New Gardner-Denver Sharpener

A new small drill steel sharpener is being offered by the Gardner-Denver Company, Quincy, Ill. The machine, known as the DS-2, is operated with two die pistons in tandem, and both are used for clamping and upsetting. One piston only is used for fullering and gauging.

A single throttle valve controls the fullering, clamping, and dollying operations. This lever is placed at the side of the machine, and its movement is smooth so that there is little fatigue on the operator.

The DS-2 weighs 1,370 pounds, and is designed to handle steel in cross section up to 1⅛ in. and to make bits having a maximum diameter of 2½ in. Standard four-point cross bits, six-point bits, and McLellan-type bits are made with regular equipment.

The hammer cylinder and dollies are designed so that little time is necessary for changing, the change being effected by loosening the clamp holding the dolly cylinder in position. The throttle lever is equipped with a safety latch, which, when in position, prevents the accidental movement of the lever and operation of the machine.

The sharpener stands 44½ in. in height, and the diameter of the base is 24 in.

New Heavy Duty Motors

A four-page leaflet describing a new mill motor has recently been announced by the Westinghouse Electric and Manufacturing Company. This new motor embodies the latest recommendations of the Association of Iron and Steel Electrical Engineers.

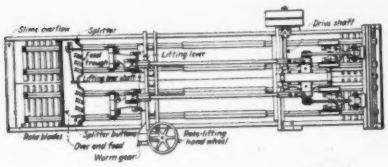
The application of the motor includes heavy duty operations such as steel mill auxiliary drives, cranes, hoists, shovels, coal and ore bridges, mine hoists, railway turn-tables, transfer tables, railway lift bridges, traffic bridges, conveyors, etc.

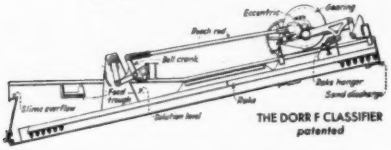
New Air-Sand Cleaning Plant

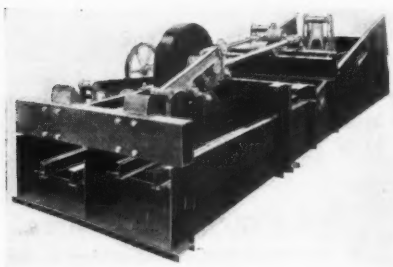
The Green River Fuel Company has contracted with the Hydrotator Company, of Pittsburgh, for installation of an air-sand coal-cleaning plant at their mine at Mogg, Muehlenberg County, Ky. The plant will handle 100 tons per hour of ⅛x2-in. coal. Special equipment is being provided to dedust the stoker coal and market it free from ⅛-in. fines. Equipment will be manufactured by the Stephens-Adamson Manufacturing Company, Aurora, Ill.

Dorr Company Introduces New Classifier

The Dorr Company, Inc., has introduced a new and improved type of mechanical classifier, known as the Dorr F Classifier. The mechanical improvements in the design and the use of an entirely new and advanced type of head motion have greatly extended its field of application, and permitted the use of higher speeds than formerly possible,





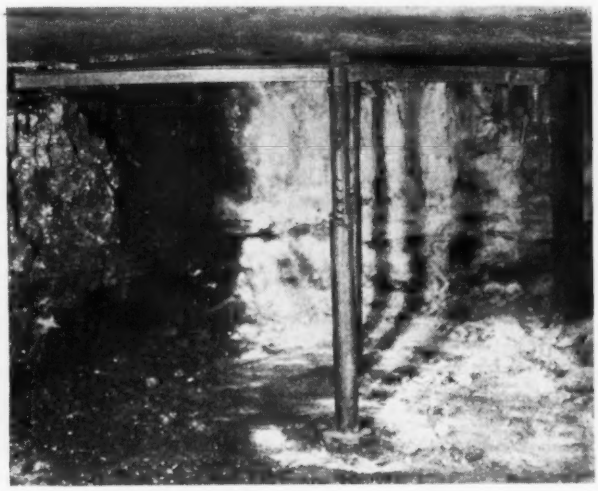


accompanied by a corresponding increase in sand-raking and overflow capacities.

The outstanding feature is a distinctly different type of head motion which is responsible for the machine's ability to operate smoothly and quietly at speeds 50 percent greater than the maximum possible previously.

The improved head motion adopted has permitted a material reduction in the head room required, giving the classifier a pronounced underslung, compact appearance. Speeds up to 50 strokes per minute are now permissible, and both sand-raking and overflow capacities have been increased. Simplification of design has reduced moving parts 22½ percent, regularly lubricated parts 33 percent and infrequently lubricated parts 50 percent.

The classifier is offered with and without the bowl for all separations from 10 to 325 mesh. The widths range from 3 ft. to 16 ft., lengths vary according to the specifications of the mills with which the classifiers are to operate in closed circuit, and the raking mechanisms are furnished in the simplex, duplex and quadruplex types.

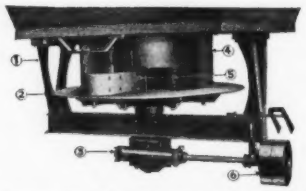


The accompanying illustration shows one of the adjustable "L. & H." roof jacks designed by the Central Mine Equipment Company, of St. Louis, as used on one side of an advancing 30-ft. room. An announcement of this jack appeared in our September issue, and this photograph is one of several received since then from J. A. Long, general manager, and M. Heard, general superintendent of coal mines, Woodward Iron Company, Woodward, Ala.

New Disc Feed Regulator

A simplified machine for metering crushed and ground materials has been designed by the Deister Concentrator Company, Fort Wayne, Ind. It is known as the Concenco Disc Feeder and will feed fine materials such as sand, ground clay and shale, as well as gravel, crushed rock, coal, etc., up to 3-in. cubes in any capacity wanted.

The outlet (see 4 on illustration) is made from steel plate rolled to size with an angle flange for bolting to the underside of the bin. The renewable disc (2) is a 60-in. steel circle made of heavy steel plate bolted to a cast iron spider. Drive is by means of worm gearing, ball thrust bearing and roller bearing equipped, running in oil and incased with dust proof housing. The worm gear shaft is driven



1—Suspension brackets can be reversed and used as supporting legs. 2—⅝-in. renewable steel disc. 3—Enclosed, self-oiling worm gear drive. 4—42-in. dia. full opening. 5—Capacity adjustment. 6—Tight and loose pulley.

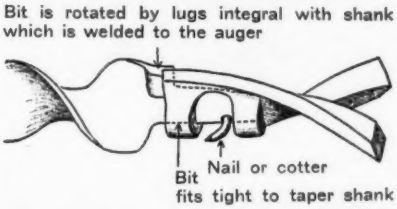
by tight and loose pulleys; it is also furnished with clutch pulley or a sprocket for chain drive. The starting and stopping of the feeder can be so arranged to work automatically with any other unit.

The discharge is controlled by the angle of the plow (5) which can be set for any capacity and adjusted to suit any condition while operating without the necessity of a shutdown. The entire assembly weighs 1,550 lbs., and can be supported on its own foundation or suspended from the underside of the bin.

Goodman Detachable Bits

The Goodman Manufacturing Company has developed a strong and economical detachable bit for mine augers.

The new bit is made in 2-in., 2¼-in. and 2½-in. sizes, weighs a little over ½ lb. and is 4 ins. long. It is made of 5/16-in. thick tool steel and may be re-



sharpened many times before it need be discarded. This steel is ordinarily forged and tempered by mine blacksmiths and therefore does not require exceptional handling. Special steels can be furnished to meet special conditions.

Difficulty with former bit designs has been overcome by neatly forming the twist to fit over a shank welded to the auger, thus assuring a smooth joint which permits free passage to the cuttings at this point.

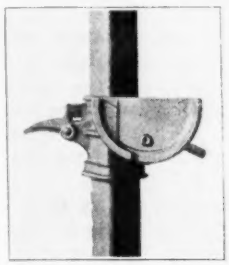
The Goodman bit fits tightly over a taper shank, thus assuring its perfect alignment with the auger and the drilling of a straight hole. A cotter or a nail passing through the end of the shank retains the bit should it become loose when withdrawing the auger from the hole. Rotation is transmitted to the bit from the auger by lugs integral with the shank.

Shanks are identical for the three sizes of bits. They are welded into a ⅝-in. slot cut into end of auger twist and may be replaced or reforged as found necessary.

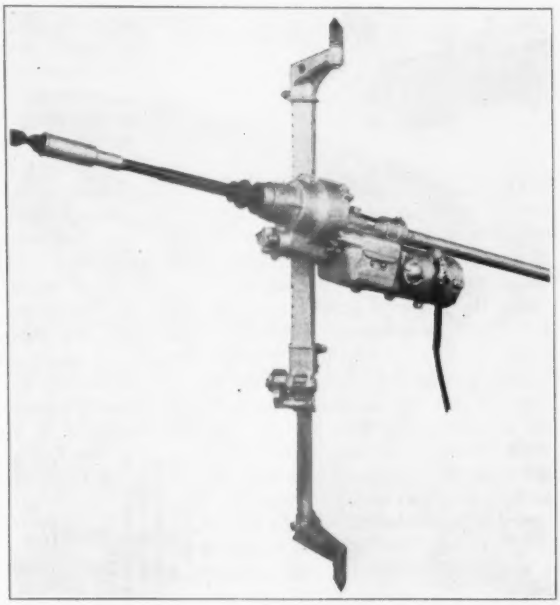
Through the use of detachable bits the unsafe practice of carrying full-length augers to and from the shop for resharpening is eliminated.

A New Type Post Drill

A post drill, entirely new in design and construction, has been introduced by the Jeffrey Manufacturing Company, Columbus, Ohio. A number of distinctive advantages are pointed out by the makers, including a differential feed mechanism; lightness in weight, making it easy to place the drill in the cradle support on the post and adjust it to drilling height; a drilling speed of 43 in. per minute; and the ability to withdraw the auger at rapid speed without reversing the direction of rotation, thereby cleaning the hole of cuttings.



The drill cradle and notched adjusting tube of the drill post is shown above. The drill is held rigidly at any angle in the cradle by means of a lock screw. The ratchet lock of the adjusting tube holds the drill at any desired height



The drill, designed as type A-6, has a motor rated at 1½ hp., with protection against overload by cartridge type fuses. It is furnished in either open type or permissible for 250 or 500 volt d. c. or 220 or 440 volt a. c. current, 3 phase, 60 cycle. The rotation of the feed bar and auger is accomplished through single reduction spur gearing, housed in an aluminum alloy case. Between the feed gear and the feed nut is a single plate friction clutch which permits the feed nut to be disengaged from the driving gear and provides a neutral or no-feed position. By use of this clutch the rate of the forward feed can be controlled. Being spring loaded so that it can not be set absolutely tight, this clutch will slip should the auger become jammed, thereby protecting the gearing, etc.

By rotating the feed nut at a speed faster than that of the thread bar, a forward feed of the thread bar based on the difference between these feeds is obtained. When this is done, the feed bar is withdrawn at a speed directly proportional to the speed of rotation. The operation of these feeds is controlled by a small hand wheel located at the auger end of the drill.

Forward speeds of 35 in. per minute and 43 in. per minute can be obtained, using feed bars of 5 threads per inch and 4 threads, respectively.

Feed speeds of 22 in. or 28 in. per minute are available by use of different gearing. The corresponding return speeds of the auger are 160 in. and 216 in. per minute, respectively.

The auger socket, riveted to the end of the thread bar, is of a new type requiring no shank on the auger. This is an advantage as it eliminates any possible bending or breaking at the shank, ordinarily the weakest point of the auger. The sockets are obtainable in sizes to take standard augers.

The drill post is square and notched, with a notched adjusting screw and a ratchet lever mechanism for adjustment as to height. The adjusting tube and the cradle for the drill are equipped with ratchet locks so that they can be set in any desired position. This permits the cradle to be lowered, the drill set in and the entire cradle and drill raised to the proper drilling height.

The drill proper without thread bar and socket weighs 108 lbs. The thread bar and socket weigh 23 lbs. and the post for 6 ft. coal weighs approximately 65 lbs.

A recent issue of the "Explosives Service Bulletin," published by E. I. du Pont de Nemours & Co., Wilmington, Del., is devoted to "Low Density Ammonia and Semi-Gelatin Dynamites." Copies may be obtained upon request.

A New Light Drill Sharpening Machine

Sullivan Machinery Company announces the introduction of something new in drill sharpening machines. The Sullivan Class "E" Sharpener has been designed to bring the advantages of mechanical sharpening and shanking of rock drill and hammer drill steel to the assistance of those mines. contractors, quarrymen, or Public Works Departments which have hitherto depended on hand blacksmithing, due to the small amount of work which they have had to do of this character, and also due to price and weight limitations.

The new sharpener makes cross or rose (6-point) bits to 2½ inches maximum gauge on ⅞-inch or 1-inch steel. It forges collar shanks and dies are available for any steel section. In addition, it forms and sharpens concrete breaker pick or chisel bits on steel as large as 1⅛-inch hexagon.

This sharpener weighs only 350 lbs. and occupies a floor area of 18 inches square. It stands just over 4 ft. in overall height and operates satisfactorily without other foundation than that provided by bolting it to the floor or to light timbers.

The portability of the "E" sharpener enables it to be kept right up with the rock drilling tools and the portable air compressor, and it can be readily dis-

assembled for animal carriage in rough country.

It employs the well-known Sullivan "all-hammer" principle, the upsetting and vertical hammers being operated by compressed air. The steel is held in the clamp for upsetting by a foot lever and togger, which permit rapid action and provide a secure and positive grip on the steel. The sharpener is operated from a portable compressor.

Bulletin 72-P will be sent upon application to the Sullivan Machinery Company at any of its branch offices, or at 400 North Michigan Avenue, Chicago.

Catalogs Describe Myers-Whaley Machines

The Myers-Whaley Company, Knoxville, Tenn., has published two catalogs thoroughly illustrated and presenting complete descriptions of their machines.

The Whaley "Automat"

One catalog covers the "automat" for coal loading underground, which is built in two sizes. The No. 3 size weighs 15,500 lbs. and is for operation in a minimum headroom of 4½ ft. from top of rail to roof, with a shovel reach of 11 ft. to each side from track center. The No. 4 weighs 19,500 lbs. and operates in a minimum headroom of 5 ft., with a reach of 12 ft. In timed tests, a capacity of six tons a minute has been shown by these machines, and in operation in average of two tons a minute is guaranteed.

The other catalog describes the Myers-Whaley Shoveling Machines for use in loading rock and ores and for tunnel mucking. This type is also made in two sizes. The No. 3 is designed to work in mines or tunnels not less than 4 ft. from rail to roof, weighs 13,550 lbs., and has a maximum capacity of 35 cu. ft. per minute in loose material. The No. 4 weighs 18,500 lbs. and is for mines or tunnels 6 ft. and over in height. It has a reach of 10 ft. to each side of center of track, and a maximum capacity of 45 cu. ft. per minute in loose material.

Although the Automat and the Shoveling Machine differ in many details of construction, they are similar in principle and operation. There is an automatic shovel mounted on the forward end of a swinging jib, which is pivoted at its rear end to the main frame. This jib section carries a conveyor which receives the material from the shovel and delivers it to a second conveyor which is also pivoted for lateral movement. The operator, mounted upon a platform at the right side of the jib section, controls the machine with four levers. One of these moves the entire machine forward and backward; a second swings the jib section; a third raises or lowers the rear conveyor, and a fourth adjusts the height of the shovel. The machine is driven by a single motor mounted upon the main frame.

The Myers-Whaley machine is a development dating from 1908 when the first machine embodying the shoveling motion principle was built and used for loading coal. In 1912 a heavier machine was used in tunnel mucking at Tallulah Falls, Ga., and shortly after one was used in the New York Aqueduct Tunnel under Ft. Greene Park, Brooklyn.

New Safety Switches

A new front-operated safety switch, designated "R.B.," of identical design with the side-operated type, but for which additional advantages are claimed, has been announced by the Trumbull Electric Manufacturing Company, Plainville, Conn. It is convenient for close ganging and for mounting on industrial switchboards where space requirements are limited. The lower half of the cover is hinged at the center and interlocked with switch handle. The slot in the end of the handle provides for "stick operation" when the switch is installed out of reach, and the handle lies close to the cover in both "on" and "off" position. The handle guard is equipped with slots for use in locking switch in either the "on" or "off" position. The cover is readily removed for switch inspection by taking out four screws.

Left—The new front-operated "R. B." safety switch

Right—The side-operated "R. B." safety switch with double-break contacts

Side Operated Switch

The Trumbull Company has also developed the "R.B." safety switch, featuring double-break contacts. The manufacturer states that this switch will operate thousands of times without deterioration of contact surface, due to the double-break contact feature which breaks the current on the outside of the current-carrying surfaces. The path of the current does not pass through any hinged, soldered or riveted connections which is said to make a strong compact unit that reduces voltage drop. Receding blade construction draws 60 percent of the arc down to a built-in "snuf-arc" chamber which is part of the moulded base. Except under heaviest load, no arc is visible, states the manufacturer. The switch is equipped with a safety interlocker which makes it impossible to open the switch until it is in the "off" position. It is available with front or side-operating handle.

Deister Machine Company

Due to some misunderstandings and apparent lack of knowledge in some sections of the mining industry, relative to the scope and activities of the Deister Machine Company, Emil Deister, president, has recently made the following announcement:

"The Deister Machine Company of Fort Wayne, Ind., has acquired from time to time since its incorporation in 1912 the exclusive right to manufacture and sale of all Deister equipment and improvements under Deister patents for which applications were made subsequent to January 1, 1912, and also other patents pertaining to ore concentrating tables, coal washing tables, coal washers, self-oiling headmotions for same, vibrating screens, classifiers, etc.

The Deister Machine Company are manufacturers of the "Plat-O" concentrating tables and classifiers, and "Plat-O" coal washing machinery and vibrating screens.

Pittsburg Boiler & Machine Co. To Market Norton Coal Washer

The Pittsburg Boiler & Machine Company, Pittsburg, Kans., engineers and manufacturers of coal tipple equipment, have acquired the manufacturing and sales rights for the Norton Automatic Coal Washer from the patentee, Mr. Bertram Norton, Tipton, Staffs, England.

The Pittsburg company has recently opened an office in Chicago, 2007 Engineering Building, in charge of C. W. Waterman, vice president in charge of sales.

MAGNITUDE *of the* COPPER INDUSTRY!

From the day of the auto to that of the autogiro, in peace and in war, through good times and bad, Copper . . . giant of metals . . . has moved consistently forward. With such a record of sound and proven strength behind it, Copper today stands confidently facing the future, well prepared for whatever demands world industry may make upon it.

The following interesting statistics covering the Copper Industry have just been released by the U. S. Bureau of Census:

Enterprises—143

Mines & Quarries—180

Officials & Salaried Employes—3,465

Wage Earners (Year's Average)—44,493

Salaries—$10,136,354

Wages—$64,849,996

Contract Work—$10,944,697

Value of Products—$283,336,884

Horsepower—701,241

Tons, Bituminous Coal—1,006,321

Tons, Coke—7,859

Gallons, Fuel Oil—89,613,817

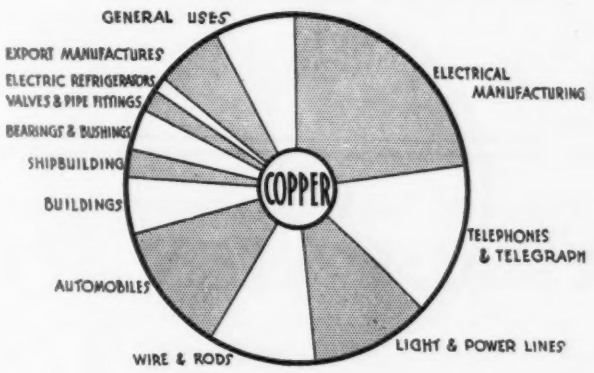
Gallons, Gasoline and Kerosene—421,317

Kilowatt Hours, Purchased Electric Energy—758,119,000

Kilowatt Hours, Generated Electric Energy—734,614,000

Cost, Equipment Purchased—$13,084,000

Cost, Supplies Purchased—$43,995,395



The above graph clearly shows the proportionate diversion of copper into industry according to recent statistics.

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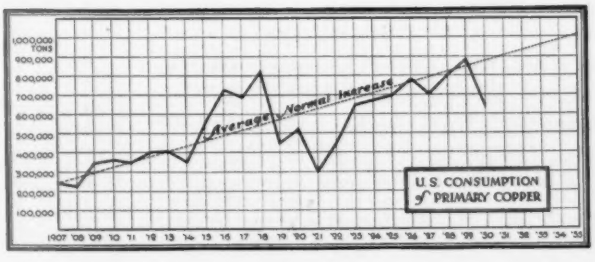


This graph indicates the tremendous increase in the use of primary copper in the U. S. during the past 23 years, an average increase of over 250%.

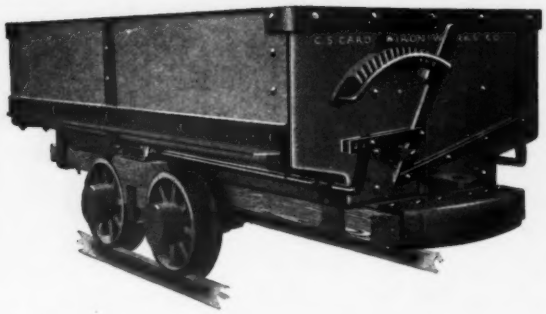
SOLID MANGANESE FROG

One feature of this frog beyond its extreme denseness and strength is the sloping design of the top surfaces of the easer extension of all ends to carry worn wheel treads over the frog without undue hammering. Rails bolted to these ends are held in alignment both vertically and horizontally. Wide guard flare openings, liberal lengths and heavy cross section with ample tie bearing surface and strong stiffening ribs help to give this solid frog exceptional long life. Write for our catalog. You may find it helpful.

THE
WEST VIRGINIA RAIL COMPANY
HUNTINGTON
WEST VIRGINIA

Rails and Accessories, Frogs, Switches, Steel Ties and Special Track Work in stock for prompt shipment.

CARD-CARS



HIGH mechanical efficiency is great stuff in mine cars—a combination of sturdy construction and simplicity of design. Card cars are efficient. Naturally, they are almost total strangers to repair shop foremen.

Replace with Card Semi-Steel Heat-Treated Wheels—if you want low-cost, trouble-free performance. Furnished to any unpatented design.

Write for Catalog J.

C.S. Card Iron Works Co.
Denver, Colorado.

CONNELLSVILLE

FANS **Connellsville mine fan wheels are rigidly constructed and run in perfect balance. Electrically welded blades are shaped and set to give highest efficiency. Drives are belt, chain, rope or direct connection. Fans are built to meet any requirements and are of exhaust, blowing or reversible types.**

Connellsville Fans combine high efficiency and sturdy construction with low installation and maintenance costs. Let us send further information.

THE CONNELLSVILLE MFG. & MINE SUPPLY CO.
CONNELLSVILLE, PENNSYLVANIA

an ideal **portable fan**

Solid cast aluminum wheel built in the same proportion as the propeller on heavy duty bombing planes.

Tripod base fastened with wing nut and easily adjustable to any desired angle.

Latest ball bearing motors used for fan. Can be furnished without motor.

Safety guard will pass the most rigid safety inspection.

Traction wheels are 14' diameter allowing easy movement over rough floors.

Steel handle aids portability and guards the motor.

Hand starter switch with overload protection is fully enclosed.

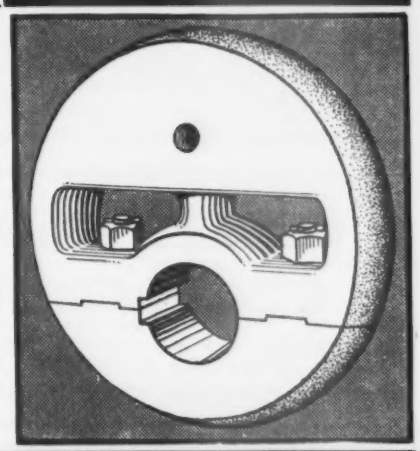
With its aluminum wheel built like a bombing plane propeller this light weight fan is ideal in copper, coal and other mines where a portable fan is needed. Blows air in penetrating cork-screw spirals. Compact and efficient, easily moved from room to room. No truck for rails required. The light weight one-piece fan wheel, mounted on the end of the motor shaft eliminates motor bearings troubles. The picture will suggest new uses to you. Let us send complete description.

ROBINSON
VENTILATING Co.
ZELIENOPLE, PENNSYLVANIA

MINE CARS
FROGS : SHAKER
DRIVING EQUIPMENT: SWITCHES

EGYPTIAN MINING EQUIPMENT

EGYPTIAN BALL-FACE SELF-OILING SELF-ALIGNING ECCENTRICS ARE CAST FROM THE FINEST SEMI-STEEL AND WILL SAVE YOU TIME, LABOR, AND MONEY.



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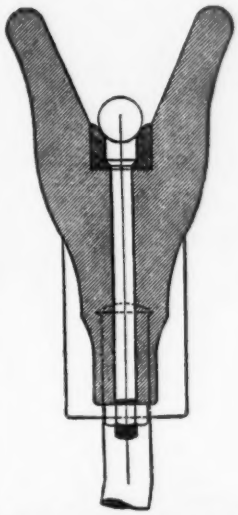

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INDEX TO ADVERTISERS

Allis-Chalmers Mfg. Co. . . . 3
American Steel & Wire Co. . . . 18
Atlas Powder Co., The . . . 10
Ayer & Lord Tie Co. . . . 19
C. S. Card Iron Works . . . 16
Connellsville Mfg. & Mine Supply Co. . . . 16
Copper & Brass Research Association . . . 11
Du Pont de Nemours Co., Inc., E. I. . . . 12, 13
Egyptian Iron Works . . . 17
Ensign-Bickford Co., The . . . Inside Front Cover
Enterprise Wheel & Car Corp. . . . 20
General Electric Co. . . . 8, 9
Giant Powder Co. . . . 10
Grasselli Chemical Co., The . . . 6
Hoffman Bros. . . . 18
Holmes & Bros., Inc., Robt. . . . 19
Jeffrey Mfg. Co., The . . . 7
Joy Mfg. Co. . . . 5
Mine Safety Appliances Co. . . . 17
Mott Core Drilling Co. . . . 18
Patrick, R. S. . . . 19
Pennsylvania Drilling Co. . . . 18
Phelps Dodge Corp. . . . 19
Robinson Ventilating Co. . . . 17
Scholz, Carl . . . 20
Stonehouse Signs . . . 20
Timken Roller Bearing Co. . . . 14
Universal Vibrating Screen Co. . . . 19
West Virginia Rail Company . . . 16

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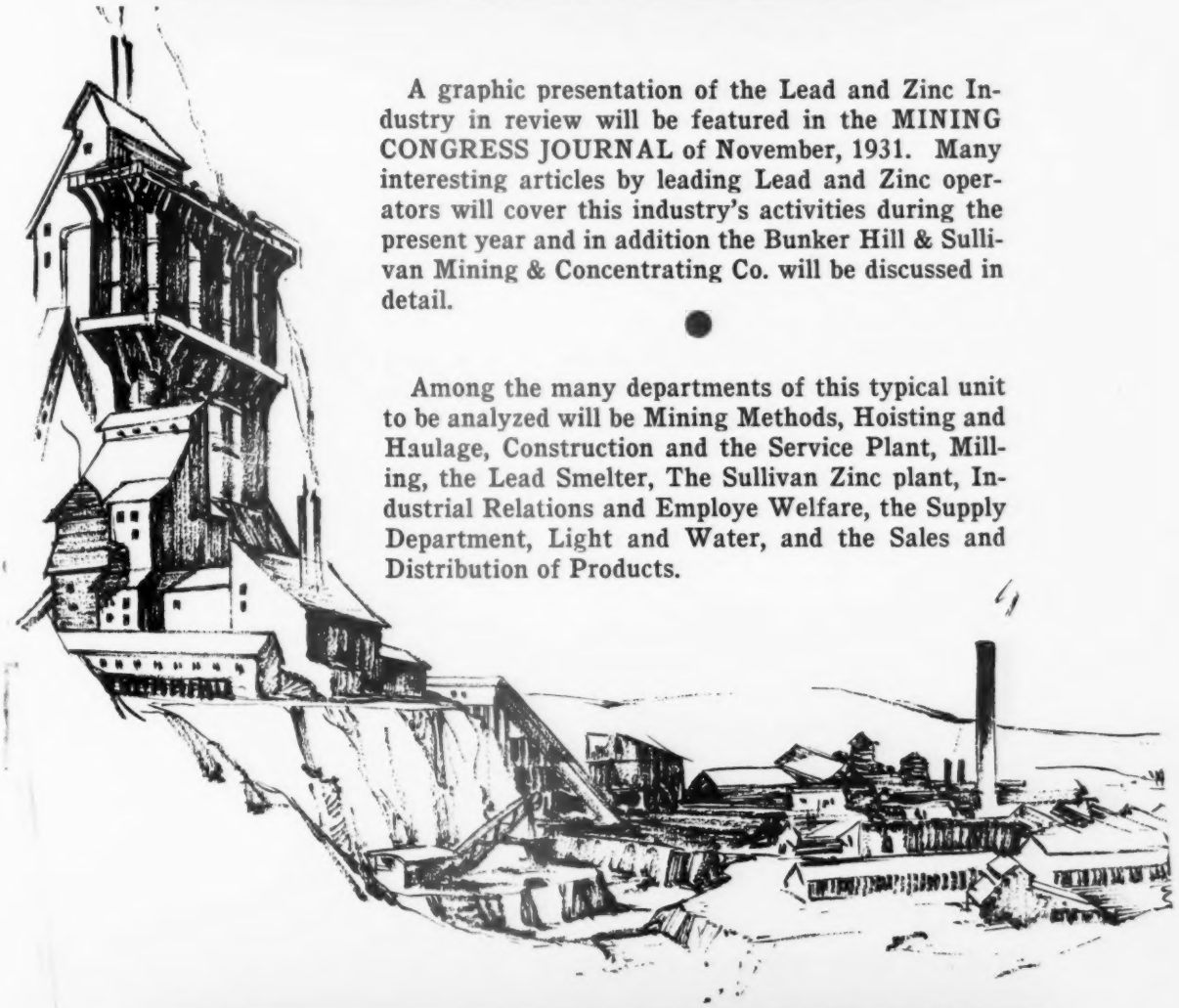

A graphic presentation of the Lead and Zinc Industry in review will be featured in the MINING CONGRESS JOURNAL of November, 1931. Many interesting articles by leading Lead and Zinc operators will cover this industry's activities during the present year and in addition the Bunker Hill & Sullivan Mining & Concentrating Co. will be discussed in detail.

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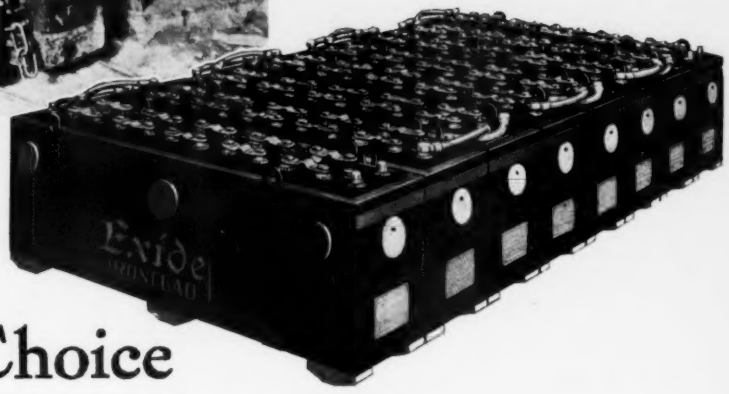

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